EXHIBIT E

EXHIBIT E-1

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Report Issued: FEB 9 1987 Report 500-87.25

PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH
3400 Crow Canyon Road
San Ramon, California 94583

LABORATORY TEST REPORT

SUBJECT: EVALUATION OF J-HOOKS AND EYES FROM 115KV OLEUM G-LINE

Introduction

Tests were conducted on two J-Hooks and two attaching plates taken from a 115 KV Oleum G-Line tower.

Both of the J-Hooks and their attaching plates had grooves worn in them and there was a concern that they may not be able to hold the weight of insulator strings that are suspended from them,(See Figures 1 and 2).

Tests were requested by Mr. G. Schauer of East Bay Region T&D.

Objective

The objective was to establish the tension required to fail the hook or the attaching plate. The ultimate rating for 115 KV lines is 30,000 Lbs., (See Manufacturers' Literature in Appendix A).

Test Procedure

The tensile test was accomplished by making a fixture to hold the hook and the plate in the same position it would be while in service and applying tension using the Tinius Olsen universal test machine, (See Figure 3). American National Standards Institute, (ANSI), B30.10-1975 was used as a guideline, (See Appendix B).

Test Results

Both hooks failed at 11,500 lbs., (See Figures 4 and 5). Since the plates did not fail during this test an additional test was done on one of the plates. A shackle was attached to the eye of the plate and tension was applied. The eye failed at 19,600 lbs., (See Figure 6).

Distribution: ESElliott
CDPaquin
GSchauer
CBScott

DATE 2/10/87
TESTED BY [signature]
APPROVED [signature]
FILE NO. 500 (6572)

2801a/mak11

Conclusion

As shown in the results the hooks failed at 11,500 Lbs. tension. According to the Manufacturers' drawings, the rating of a 115 KV line supporting hook is 30,000 Lbs. Because of the low failure points of the two hooks, an additional hook was brought in and tested. This hook had no visible grooves or scratching in the surface as the two samples in the original test did.

The hook failed at 6900 Lbs.

Recommendation

The hook without visible flaws failed at 6900 Lbs. and the rating for these hooks is 30,000 Lbs.. This would suggest that a test be done on some random samples of different manufacturers' hooks from PG&E stores to check their strength against their specifications.

Figure 1. As shown in the Figure above a wear pattern was formed in the bowl-saddle of the J-Hook. This was possibly caused by the insulator string swinging in the wind over a period of time.

Figure 2. This Figure shows the key-hole wear in the plate eye caused by the J-Hook while in service.

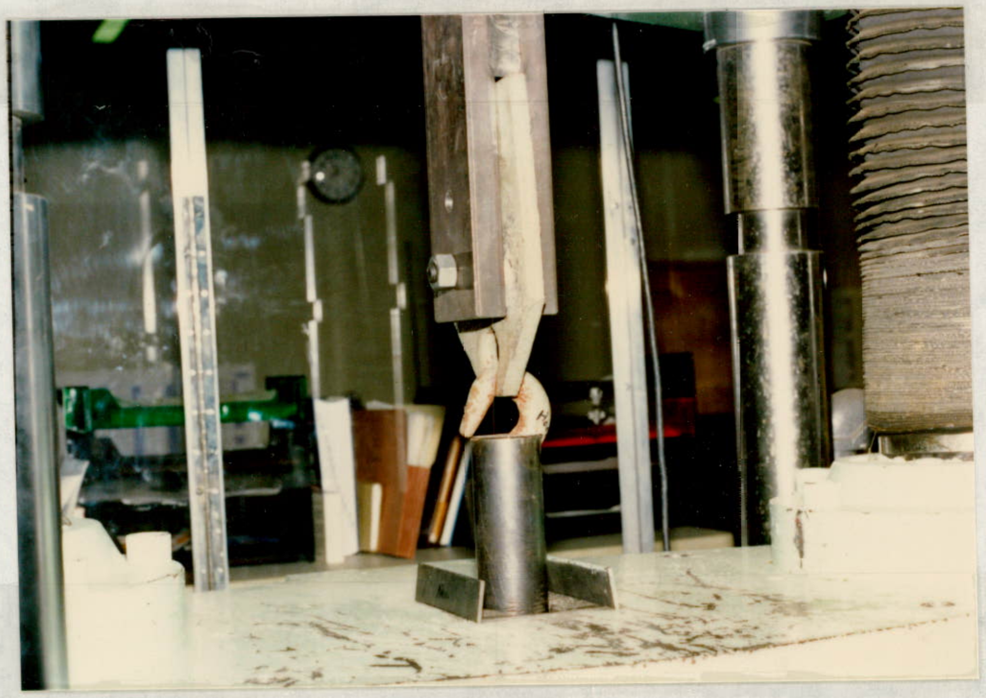


Figure 3. This shows the fixture holding the plate and J-Hook in the simulated position it would be in service.

Figure 4. This hook shows the point of failure to be in the worn section of the bowl-saddle.

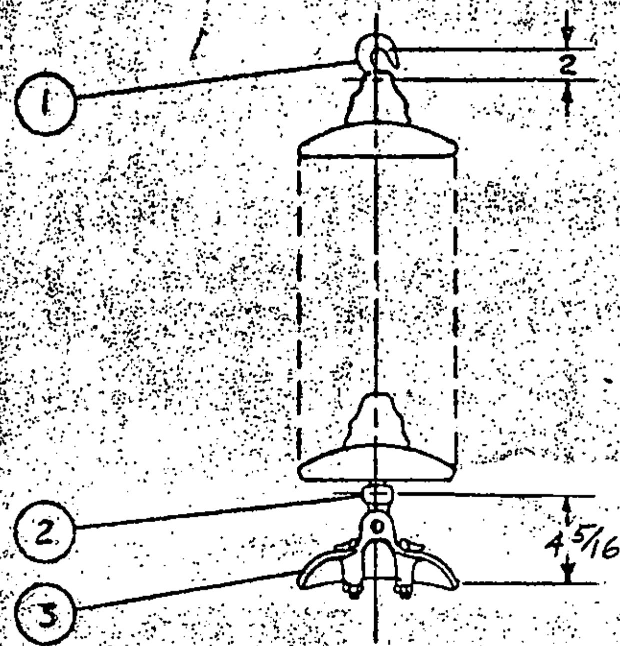
Figure 5. This hook failed at the heel even though it had approximately the same wear pattern in the bowl-saddle as the hook in Figure 4.

Figure 6. This Figure shows the failure of the eye in the plate when a shackle was pulled through it.

APPENDIX A

Manufacturers Literature and Company Standards

REVISIONS: DATE | NO. | DESCRIPTION | BY



PG&E CODE	CAT. NO.	TYPE
11-0145	C-11075	SC

NOTES:

1. REFERENCE: PACIFIC GAS & ELECTRIC DWG. NO.-056414 SHT. 3 TYPE -SC
2. ASSEMBLY RATING- 16,000 LBS.
3. CLAMPING RANGE- .200 - .600

P. G. & E. DRAWING NO. 690134

ITEM NO.	PART NO	DESCRIPTION	MATERIAL	ULT. STR. LBS.	QTY	SPEC. NO.	WEIGHT
1	HB-30	HOOK BALL	GALV. FORGED STEEL	30,000	1	ASTM A-153-64	1.00
2	SA-04	EYE SOCKET	GALV. DUCTILE IRON	20,000	1	ASTM A536-65T	1.25
3	BRS-60-N	SUSP. CLAMP	112 ALUM. BRZ.	16,000	1	ANDERSON 2000	2.90

[redacted]

MR-1960

R/0

DATE 3-4-76	44-115 KV SINGLE STRING SINGLE CONDUCTOR SUSPENSION ASSY.
DWN BY: [illegible] CKD BY: [illegible]	ANDERSON ELECTRIC CORP. LEEDS ALABAMA
APPROVED HEL	CAT. NO. C-11075
SCALE DO NOT	DWG. NO. C-11075

APPENDIX B

ANSI B30.10-1975

AMERICAN NATIONAL STANDARD

SAFETY STANDARDS FOR CABLEWAYS, CRANES, DERRICKS, HOISTS, HOOKS, JACKS, AND SLINGS

HOOKS

ANSI B30.10 - 1975

SECRETARIAT

NAVAL FACILITIES ENGINEERING COMMAND,
U.S. DEPARTMENT OF THE NAVY
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLISHED BY

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

United Engineering Center 345 East 47th Street New York, N. Y. 10017

FOREWORD

This American National Standard, Safety Standards for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks and Slings, has been developed under the procedures of the American National Standards Institute (formerly the United States of America Standards Institute). This specific standard had its beginning in December 1916, with a Code of Safety Standards for Cranes, prepared by an ASME committee on the Protection of Industrial Workers, was presented to the annual meeting of the ASME.

Meetings and discussions regarding safety on cranes, derricks and hoists were held from 1920 to 1925, involving the ASME Safety Code Correlating Committee, the Association of Iron and Steel Electrical Engineers, the American Museum of Safety, the American Engineering Standards Committee (later changed to American Standards Association and subsequently to the USA Standards Institute). Department of Labor, State of New Jersey, Department of Labor and Industry, State of Pennsylvania, and Locomotive Crane Manufacturers Association. On June 11, 1925 the American Engineering Standards Committee approved the ASME Safety Code Correlating Committee's recommendation and authorized the project with U.S. Department of the Navy, Bureau of Yards and Docks and the ASME as sponsors.

In March 1926 invitations were issued to 50 organizations to appoint representatives to a Sectional Committee. The call for organization of this Sectional Committee was sent out October 2, 1926 and the Committee organized November 4, 1926 with 57 members representing 29 national organizations. From the 3-page document, referred to in the first paragraph, came the Safety Code for Cranes, Derricks, and Hoists ASA B30.2-1943. This document was reaffirmed in 1952 and widely accepted as a Safety Standard.

Due to the changes in design, advancement in techniques, and general interest of labor and industry in safety, the Sectional Committee now known as the American National Standards Committee, under joint sponsorship of the ASME and the Naval Facilities Engineering Command–U.S. Department of the Navy–was reorganized on January 31, 1962 with 39 members representing 27 national organizations. At the time B30.3 was approved by the Committee, the membership had increased to 57 members and alternates representing 36 organizations.

The format of the previous Code was changed so that separate Standards, each complete as to construction and installation; inspection, testing, and maintenance; and operation, will cover the different types of equipment included in the scope of B30.

This Standard presents a coordinated set of rules which may serve as a guide to government and other regulatory bodies and municipal authorities responsible for the guarding and inspection of the equipment falling within its scope. The suggestions leading to accident prevention are given both as mandatory and advisory provisions and compliance with both types may be required by employers of their employees.

This Standard, which was approved by the American National Standards Committee B30 and by the two sponsor organizations, was approved and designated as an American National Standard by the American National Standards Institute on November 14, 1975.

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AMERICAN NATIONAL STANDARD

SAFETY STANDARDS FOR CABLEWAYS, CRANES, DERRICKS, HOISTS, HOOKS, JACKS AND SLINGS

INTRODUCTION

General

This Standard is one of a series of safety standards on various subjects which have been formulated under the general auspices of the American National Standards Institute. One purpose of the Standard is to serve as a guide to governmental authorities having jurisdiction over subjects within the scope of the Standard. It is expected, however, that the Standard will find a major application in industry, serving as guide to both manufacturers of the equipment and to the purchasers and users of the equipment.

For the convenience of the user, the Standard has been divided into separate volumes such as the following:

- B30.1 Jacks
- B30.2 Overhead & Gantry Cranes
- B30.3 Hammerhead Tower Cranes
- B30.4 Portal, Tower and Pillar Cranes
- B30.5 Crawler, Locomotive and Truck Cranes
- B30.6 Derricks
- B30.7 Base Mounted Drum Hoists
- B30.8 Floating Cranes and Floating Derricks
- B30.9 Slings
- B30.10 Hooks
- B30.11 Monorail Systems and Underhung Cranes
- B30.12 Handling Loads Suspended from Rotorcraft
- B30.13 Controlled Mechanical Storage Cranes
- B30.14 Side Boom Tractors
- B30.15 Mobile Hydraulic Cranes
- B30.16 Overhead Hoists
- B30.17 Single Girder Top Running Cranes
- B30.18 Overhead Stacker Cranes
- B30.19 Cableways
- B30.20 Below the Hooklifting Devices

If adopted for governmental use, the references to other national codes and standards in the specific volumes may be changed to refer to the corresponding regulations of the governmental authorities.

The use of cranes, derricks, hoists, hooks, jacks and slings is subject to certain hazards that cannot be met by mechanical means, but only by the exercise of intelligence, care and common sense. It is therefore essential to have competent and careful operators, physically and mentally fit, trained in the safe operation of the equipment and the handling of the loads. Serious hazards are overloading, dropping or slipping of the load caused by improper hitching or slinging, obstruction to the free passage of the load, using equipment for a purpose for which it was not intended or designed.

The standards committee fully realizes the importance of proper factors of safety, minimum or maximum sizes and other limiting dimensions of wire rope and their fastenings, sheaves, drums and similar equipment covered by the Standard, all of which are closely connected with safety. Safe sizes, strengths, and similar criteria are dependent on many different factors, often varying with the installation and uses. These factors also depend on the condition of the equipment or material; on the loads; on the acceleration, or speed of the ropes, sheaves or drums; on the type of attachments; on the number, size and arrangement of sheaves, or other parts; on weather, and other atmospheric conditions tending toward corrosion, or wear; and on so many variable factors that must be considered in each individual case. The rules given in the Standard must be interpreted accordingly and judgment used in deter-

mining their application.

The standards committee will be glad to receive criticisms of the Standard requirements and suggestions for the improvement, especially such as are based on actual experience in the application of the rules. Revised editions will be issued from time to time with such changes as experience in its application and improvements in the arts may dictate.

Section I Scope

This Standard applies to the construction, installation, operation, inspection and maintenance of jacks; power operated cranes, monorails and crane runways; power operated and manually operated derricks and hoists; lifting hooks and slings.

This Standard does not apply to track and automotive jacks, railway or automobile wrecking cranes, shipboard cranes, shipboard cargo handling equipment, well drilling derricks, skip hoists, mine hoists, truck body hoists, car or barge pullers, lever operated pulling devices, conveyors, excavating equipment nor to equipment coming within the scope of the following American National Standards Committees: A10, A17, A90, A92, A113, A120, B56 and B77.

Section II Purpose

This Standard is designed (1) to guard against and minimize injury to workers and otherwise provide for the protection of life, limb, and property by prescribing minimum safety requirements, (2) to provide direction to owners, employers, supervisors and others concerned with, or responsible for its application and (3) to guide governments and other regulatory bodies in the development, promulgation, and enforcement of appropriate safety directives.

Section III Exceptions and Interpretations

In case of practical difficulties or new developments, or unnecessary hardship, the administrative or regulatory authority may grant exceptions from the literal requirements or permit the use of other devices or methods, but only when it is clearly evident that an equivalent degree of protection is thereby secured.

NOTE: To secure uniform application and interpretation of this Standard, administrative or regulatory authorities are urged, before rendering decisions on disputed points, to consult the committee which formulated it through the office of The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, New York 10017.

Section IV New and Old Installations

One year after the date on which this Standard becomes effective, all new construction and installations shall conform to its rules. The performance of any equipment installed prior to one year after the effective date shall be evaluated by a qualified person selected by the user. If past performance discloses actual circumstances that have caused or might have caused property/equipment damage or injuries to personnel resulting from functional performance or from the configuration of the equipment that result from deviation of the equipment from the Standard the equipment shall be evaluated to determine specifically how it deviates from this Standard. A qualified person, having made this evaluation, shall then recommend the degree to which changes should be made to bring the equipment into compliance with the intent of this Standard and changes should be accomplished within two years from the effective date. A complete record of the evaluations, recommended changes and actual changes shall be retained.

Section V Mandatory and Advisory Rules

Mandatory rules of this Standard are characterized by the use of the work "shall". If a provision is of an advisory nature it is indicated by the use of the word "should" and is a recommendation considered to be the advisability of which depends on the facts in each situation.

CHAPTER 10-0

SCOPE, DEFINITIONS, REFERENCES

Section 10-0.1 Scope of B30.10

Within the general scope defined in Section I, American National Standard B30.10 applies to all types of hooks used in conjunction with equipment described in other volumes of the B30 standards. This applies to all hoisting hooks that support a load in a direct-pull configuration and such load is carried in the base (bowl-saddle) of the hook. This also applies to other hooks specifically defined within this chapter that do not support a load in a direct-pull configuration.

Section 10-0.2 Definitions

10-0.2.1 Administrative or Regulatory Authority. Governmental Agency or the employer in the absence of governmental jurisdiction.

10-0.2.2 Appointed. Assigned specific responsibilities by the employer or the employer's representative.

10-0.2.3 Crack. A crevice type discontinuity of the material.

10-0.2.4 Designated. Selected or assigned by the employer or the employer's representative as being qualified to perform specific duties.

10-0.2.5 Dye Penetrant Testing. A non-destructive test method for detecting surface discontinuity based on capillary action. A liquid penetrant is applied to the surface. The excess penetrant is then removed and any subsequent bleeding indicates seams, laps, and cracks.

10-0.2.6 Forging Lap. A defect caused by folding over surface metal and then forging into the material surface without cohesion.

10-0.2.7 Heavy Service. Service which involves operating at 85 percent to 100 percent of rated capacity as a regular specified procedure.

10-0.2.8 Hot Tear. A defect caused by the rupture of metal while cooling from the molten to the solid state.

10-0.2.9 Latch. A device used to bridge the throat opening of a hook.

10-0.2.10 Load. The total weight imposed on the hook.

10-0.2.11 Magnetic Particle Testing. A non-destructive test method for revealing discontinuities in ferromagnetic materials, by means of finely divided magnetic particles applied to the magnetized part.

10-0.2.12 Nick or Gouge. Sharp notch in hook surface which may act as stress raiser in the area of the notch.

10-0.2.13 Normal Service. Service which involves operating at less than 85 percent rated capacity except for isolated instances.

10-0.2.14 Proof Load. The specific load applied in performance of the proof test.

10-0.2.15 Proof Test. A non-destructive load test made by the hook manufacturer to verify construction and workmanship of the hook.

10-0.2.16 Qualified. A person who, by possession of a recognized degree, certificate or professional standing or who by extensive knowledge, training, and experience, has demonstrated the ability to solve problems relating to the subject matter and work.

10-0.2.17 Radiography. A non-destructive test employing x-ray or gamma radiation for revealing internal discontinuities.

10-0.2.18 Rated Load (R/L). The maximum allowable working load.

10-0.2.19 Seam. A crack-like discontinuity caused by rolling or working in defects.

10-0.2.20 Severe Service. Heavy service coupled with the possibility of abnormal unforeseen conditions.

10-0.2.21 Ultrasonic Testing. A non-destructive test method for revealing discontinuities in dense homogenous materials, by means of acoustic waves of frequencies above the audible range.

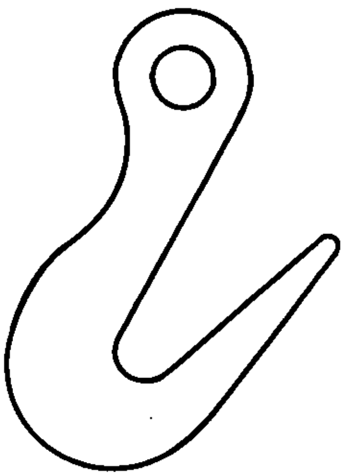


FIG. 1 SORTING HOOK

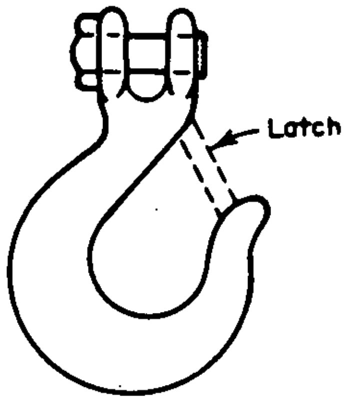


FIG. 2 CLEVIS HOOK
(Latch is optional)

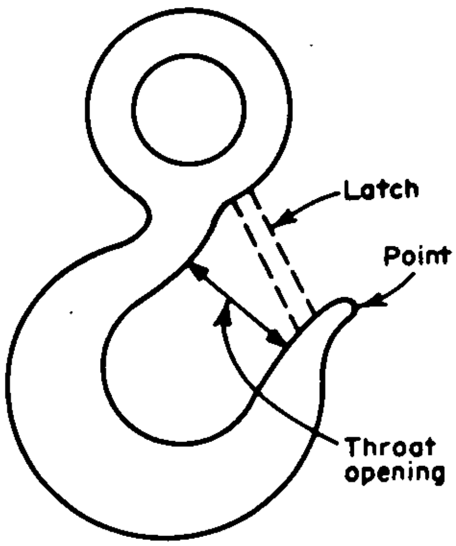


FIG. 3 EYE HOOK
(Latch is optional)

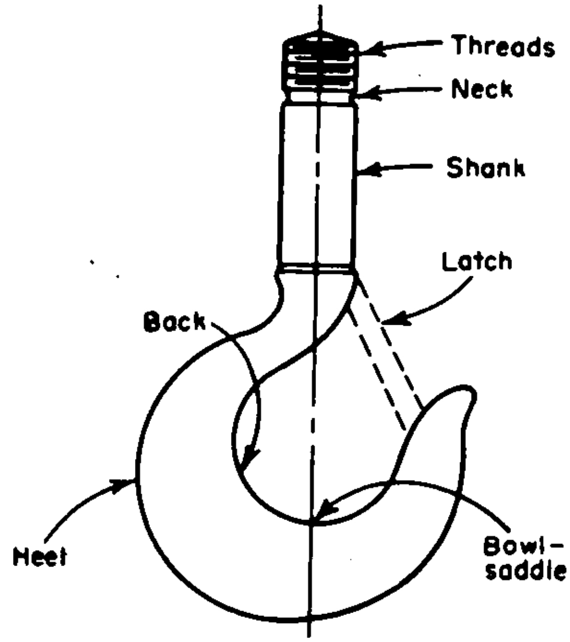


FIG. 4 SHANK HOOK
(Latch is optional)

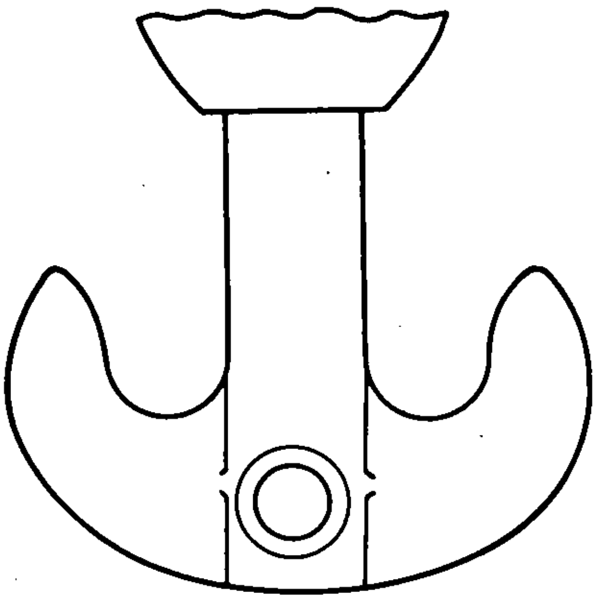


FIG. 5 DUPLEX HOOK (SISTER)
(Pinhole is optional)

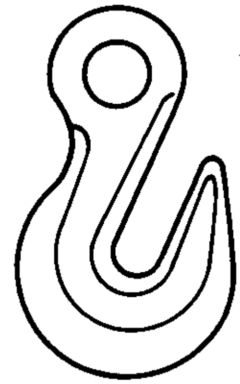


FIG. 6 EYE GRAB HOOK

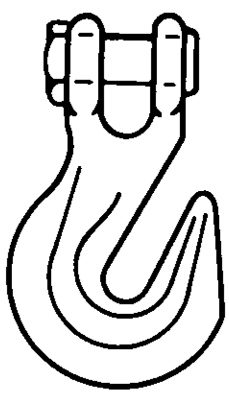


FIG. 7 CLEVIS GRAB HOOK

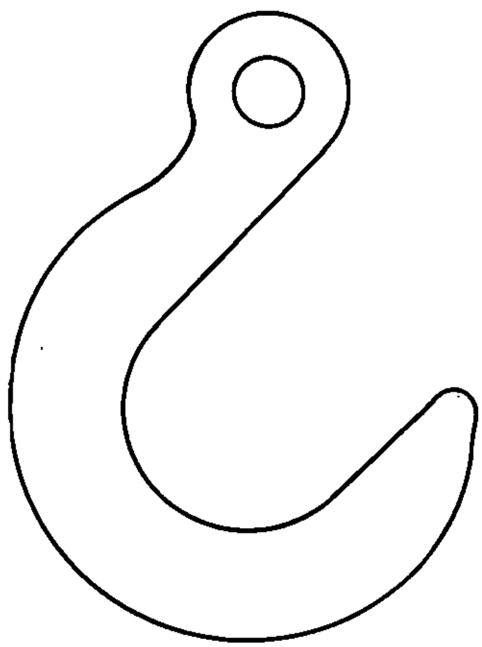


FIG. 8 FOUNDRY HOOK

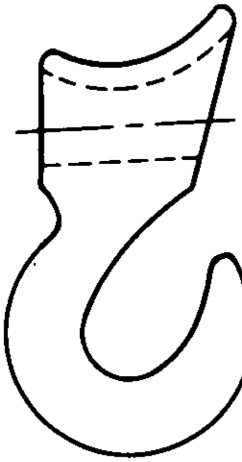


FIG. 10 CHOKER HOOK

FIG. 9 LAMINATED HOOK

CHAPTER 10-1
HOOKS, HOISTING

This chapter applies to all hooks that support a load in a direct pull configuration and such load is carried in the base (bowl-saddle) of the hook. Refer to Figures 2, 3, 4, 5 and 9.

Section 10-1.1 Hook Characteristics

10-1.1.1 The hook material shall have sufficient ductility to permanently deform before failure at the temperatures at which the specific hook will be used.

10-1.1.2 When proof tests are used to verify manufacturing process, material or configuration, the hooks shall be able to withstand the proof load application without permanent deformation when the load is applied for a minimum of 15 seconds. This condition shall be considered to have been satisfied if the permanent increase in the throat opening does not exceed 1/2 percent. For such tests, Table 1 states the proof load that shall be applied to a hook with a rated load capacity.

10-1.1.3 For a duplex (sister) hook having a pin eye, the proof load for the eye shall be in accordance with Table 1.

Section 10-1.2 Hook Identification

Manufacturer's identification should be forged, cast or die stamped on a low stress and non-wearing area of the hook.

Section 10-1.3 Attachments

10-1.3.1 Where required, a latch shall be provided, or a hook's design shall be used to retain such items as, but not limited to, slings and chains under slack conconditions.

10-1.3.2 When a handle or latch support is welded to a hook, whose design requires heat treating, welding shall be done prior to final heat treating.

Table 1 Proof Test Load

Rated Load		Proof Load (Minimum)		
Tons (2000 lbs)	Kg	Percent of R/L	Tons (2000 lbs)	Kg
1/2	453.6	200	.1	907.2
1	907.2	200	2	1814.4
5	4536	200	10	9072
10	9072	200	20	18144
15	13608	200	30	27216
20	18144	200	40	36288
25	22680	200	50	45360
30	27216	200	60	54432
35	31752	200	70	63504
40	36288	200	80	72576
45	40824	200	90	81648
50	45360	200	100	90720
60	54432	193	116	105235.2
75	68040	183	137	124286.4
100	90720	166	166	150595.2
125	113400	150	188	170553.6
150	136080	133	200	181440
175	158760	133	233	211377.6
200	181440	133	266	241315.2
250	226800	133	333	302097.6
300	272160	133	399	361972.8
350	317520	133	465	421848
400	362880	133	532	482630.4
450	408240	133	598	542505.6
500	453600	133	665	603288
Above 500	>453600	133		

Note: 1 ton (short, 2000 lbs) = 907.2 Kg

For hooks with rated load ratings not shown in the above table, use the next lower rated load rating for determining the percent of rated load to be applied as excess load.

Section 10-1.4 Inspection, Performance Testing and Maintenance

10-1.4.1 Inspection Classification

a. *Initial Inspection.* Prior to initial use, all new and repaired hooks shall be inspected to assure compliance with the provisions of **10-1.4.2**.

b. Inspection procedure for hooks shall be governed by the kind of equipment in which they are used. When such requirements for hooks are stated in standards for these specific equipments, they shall take precedence over the following. Otherwise there shall be two general classifications based upon intervals at which examination shall be performed. The classifications are herein designated "frequent" and "periodic" with intervals between examinations as defined below:

1. *Frequent Inspection*—Visual examinations by the operator other designated personnel with records not required of items listed in **10-1.4.2**:

a. Normal service—Monthly

b. Heavy service—Weekly to Monthly

c. Severe service—Daily to Weekly

d. Special or infrequent service as authorized by qualified person—before and after each occurrence with records of the operation.

2. *Periodic Inspection*—Visual inspections by appointed person making records of apparent external contidions to provide the basis for continuing evaluation as noted in **10-1.4.3**:

a. Normal Service—Equipment in place—Yearly.

b. Heavy Service—As in **10-1.4.1**.b.2a unless external conditions indicate that disassembly should be done to permit detailed inspection—Yearly.

c. Severe Service—As in **10-1.4.1**.b.2b except that the detailed inspection may show the need for use of non-destructive type of testing—Quarterly.

d. Special or infrequent service as authorized by a qualified person—before the first such occurrence and as directed by the qualified individual for any subsequent occurrences.

10-1.4.2 Frequent Inspection

Hooks in regular use should be examined for the following items as noted in **10-1.4.1** (See **10-1.4.6**)

a. Distortion such as bending, twisting or increased throat opening.

b. Wear

c. Cracks, severe nicks or gouges.

d. Latch engagement, damaged or malfunctioning latch (if latch is provided).

e. Hook attachment and securing means.

10-1.4.3 Periodic Inspection

Hooks in regular use should be inspected for the deficiencies listed in **10-1.4.2**.

10-1.4.4 Hooks not in regular use

Hooks not in regular use should be inspected in accordance with **10-1.4.2** before being returned to service.

10-1.4.5 Performance Testing

No performance testing of hooks shall be required except as is necessary to conform to the requirements for the equipment of which they are a part.

10-1.4.6 Maintenance

a. Hooks having any of the following deficiencies shall be removed from service, unless a qualified person approves their continued limited use:

1. Crack(s)

2. Wear exceeding 10 percent (or as recommended by the manufacturer) of the original dimension.

3. A bend or twist exceeding 10 degrees from the plane of the unbent hook.

4. Increase in throat opening exceeding 15 percent or as recommended by the manufacturer.

5. If a latch is provided and it becomes inoperative because of wear or deformation, or fails to fully bridge the throat opening, the hook should be removed from service until the device has been repaired or replaced.

6. If hooks are painted, a visual inspection should take this coating into consideration. Surface variations can disclose evidence of heavy or severe service to require more detailed analysis of paragraph **10-1.4.1**.b.2b or **10-1.4.1**.b.2c. The surface condition may then call for stripping the paint in such instances.

b. Repair of nicks and gouges may be carried out by a designated person by grinding longitudinally following the contour of the hook, provided that no di-

mension is reduced more than 10 percent (or as recommended by the manufacturer) of its original value (A qualified person may authorize continued use if the reduced area is not critical.)

c. All other repairs shall be performed by the manufacturer or other qualified person.

Section 10-1.5 Operating Practices

Personnel using hooks shall be instructed in the following practices:

a. Determine that the weight of the load to be lifted does not exceed the load rating of the hook.

b. Shock loading shall be avoided.

c. Load shall be centered in the base (bowl-saddle) of the hook to prevent point loading of the hook.

d. Hooks shall not be used in such a manner as to place a side or backload on the hook.

e. When using a device to bridge the throat opening of the hook, care shall be used that the load in no way is carried by the bridging device.

f. Hands and fingers shall be kept from between hook and load.

g. Duplex (sister) hooks shall be loaded equally on both sides unless the hook is specifically designed for single loading.

h. The pin hole in Duplex (sister) hooks shall not be loaded beyond the rated load of the hook.

CHAPTER 10-2
HOOKS, MISCELLANEOUS

This chapter applies to all hooks that do not support a load in a direct pull configuration; such as, grab hooks, foundry hooks, sorting hooks, and choker hooks. Refer to Figures 1, 6, 7, 8 and 10.

Section 10-2.1 Hook Properties

10-2.1.1 The hook material shall have sufficient ductility to permanently deform before failure at the temperatures at which the specific hook will be used.

10-2.1.2 Rated loads for a hook, when used in the manner for which intended, shall be equal to or exceed the rated load of the chain, wire rope or other suspension members to which it is attached. In those instances when this is not feasible, special precautions shall be taken to assure that the rated load limit of the hook is not exceeded.

Section 10-2.2 Hook Identification

Manufacturer's identification should be forged, cast or die stamped on a low stress and non-wearing area of the hook.

Section 10-2.3 Inspection, Performance Testing and Maintenance

10-2.3.1 Inspection Classification

a. *Initial Inspection.* Prior to initial use, all new and repaired hooks shall be inspected to assure compliance with the provisions of **10-2.3.2**.

b. Inspection procedure for hooks shall be governed by the kind of equipment in which they are used. When such requirement for hooks are stated in standards for these specific equipments, they shall take precedence over the following. Otherwise there shall be two general classifications based upon intervals at which examination shall be performed. The classifications are herein designated "frequent" and "periodic" with intervals between examinations as defined below:

1. *Frequent Inspection*—Visual examinations by the operator or other designated personnel with records not required of items listed in **10-2.3.2**:
   a. Normal service—Monthly
   b. Heavy service—Weekly to Monthly
   c. Severe service—Daily to Weekly
   d. Special or infrequent service as authorized by qualified person before and after each occurrence with records on the operation.

2. *Periodic Inspection*—Visual inspections by appointed person making records of apparent external conditions to provide the basis for continuing evaluation as noted in **10-2.3.3**:
   a. Normal service—Equipment in place—Yearly.
   b. Heavy service—as in **10-2.3.1**.b.2a unless external conditions indicate that disassembly should be done to permit detailed inspection—Yearly.
   c. Severe service—as in **10-2.3.1**.b.2b except that the detailed inspection may show the need for use of non-destructive type of testing—Quarterly.
   d. Special or infrequent service as authorized by a qualified person—before the first such occurrence and as directed by the qualified person for any subsequent occurrences.

10-2.3.2 Frequent Inspection

Hooks in regular use should be examined for the following items as noted in **10-2.3.1**.b.1. (See **10-2.3.6**)

a. Distortion such as: bending, twisting, or increased throat opening.

b. Wear.

c. Cracks, severe nicks or gouges.

d. Hook attachment and securing means.

10-2.3.3 Periodic Inspection

Hooks in regular use should be inspected for the deficiencies listed in **10-2.3.2** as noted in **10-2.3.1**.b.2.

10-2.3.4 Hooks not in regular use

Hooks not in regular use should be inspected in accordance with **10-2.3.2** before being returned to service.

10-2.3.5 Performance Testing

No performance testing of hooks shall be required except as is necessary to conform to the requirements for the equipment of which they are a part.

10-2.3.6 Maintenance

a. Hooks having any of the following deficiencies shall be removed from service, unless a qualified person approves their continued limited use:

1. Crack(s)
2. Wear exceeding 10 percent (or as recommended by the manufacturer) of the original dimension.
3. A bend or twist exceeding 10 degrees from the plane of the unbent hook, or as recommended by the manufacturer.
4. Increase in throat opening exceeding 15 percent, or as recommended by the manufacturer.

b. Repair of nicks and gouges may be carried out by a designated person by grinding longitudinally following the contour of the hook, provided that no dimension is reduced more than 10 percent (or as recommended by the manufacturer) of its original value (A qualified person may authorize use if the reduced area is not critical).

c. All other repairs shall be performed by the manufacturer or other qualified person.

Section 10-2.4 Operating Practices

10-2.4.1 Personnel using miscellaneous hooks shall be instructed in the following practices:

a. Determine that the load or force required does not exceed the rated load of the hooks assembly, especially when any special conditions, such as choking or grabbing, are considered.

b. Shock loading shall be avoided.

c. A hook shall not be used in a manner other than that for which it was intended.

d. Hands and fingers shall be kept from between load and hook.

* * * NOTICE * * *

THIS REPORT CONTAINS ADDITIONAL MEDIA!

MEDIA COULD BE IN THE FORM OF:
PHOTOS, CHARTS, DIAGRAMS, FILM, MAPS ETC.

ADDITIONAL MEDIA IS MAINTAINED WITH THE:
ORIGINAL HARD COPY REPORT

PG & E (ATS)

The following document(s) was not scanned by DataBank due to:

☐ Fragile State of document

☑ Outside the scope for scanning equipment

VHS Tapes

Film Negatives

CD/DVD

Video Device

☐ Customer Requirements

☐ Other

Box Number:

144

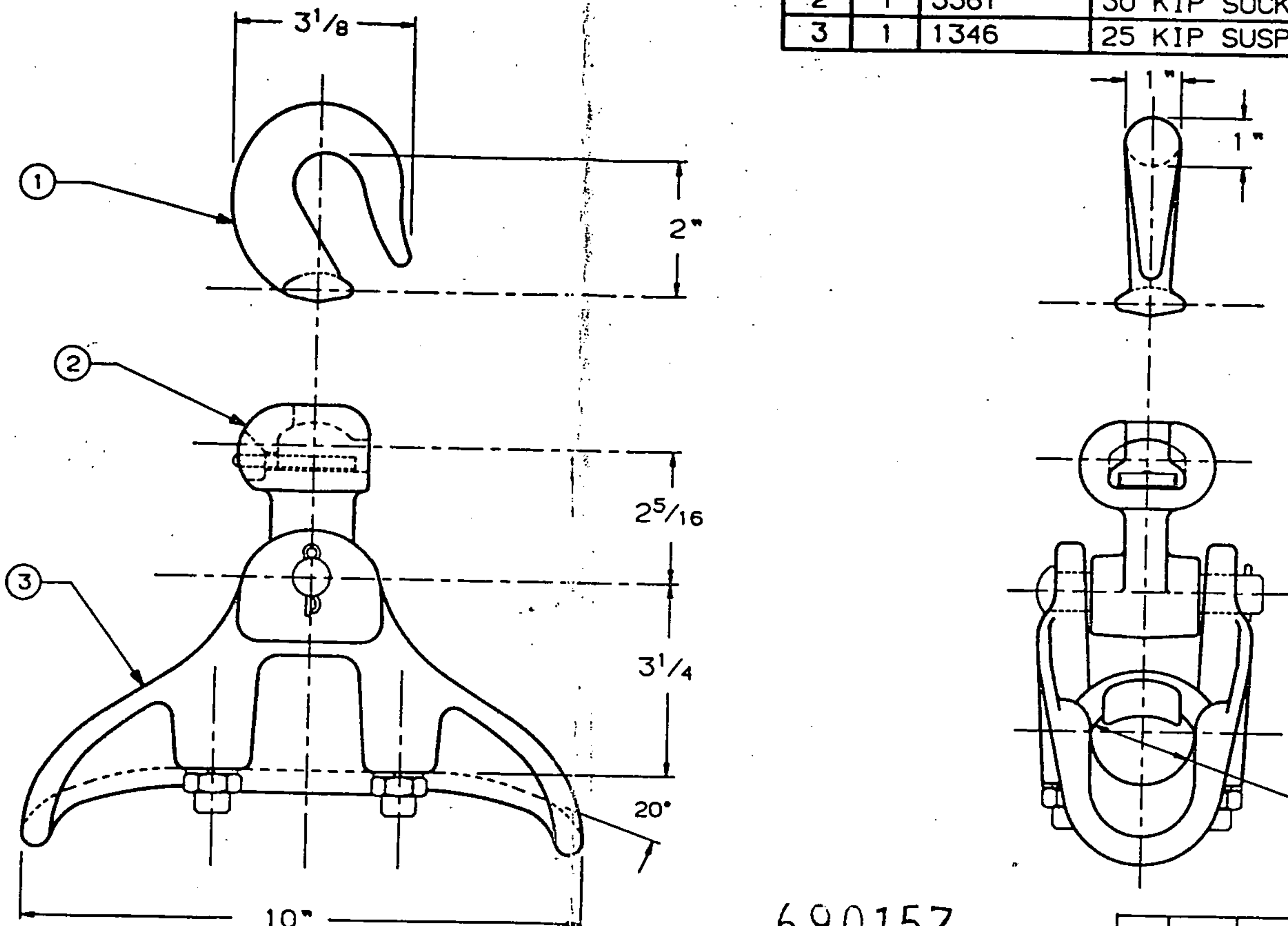
File/Folder Description:

Report number 500-87.25

1 out of 1 Negative

500-87.25

ITEM NO.	QTY.	LINDSEY PART NO.	DESCRIPTION	MAT'L	ASTM	WT. EA.
1	1	3310	30 KIP BALL HOOK	FS	A-576	
2	1	3361	30 KIP SOCKET EYE	DI	A-536	
3	1	1346	25 KIP SUSP. CLAMP	AL	B-26	



PACIFIC GAS AND ELECTRIC CO. REC'D ENGINEERING

APPROVED FOR MICROFILMING

690157

NO.	DATE	BY	APP.	DESCRIPTION
B	10-23-86	KS	MC	ADDED NOTE 3 REVISED AND UPDATED
A	2-4-85	MC		3-1/4 WAS 3-1/8 3361 WAS 3365, 10" WAS 11"

REVISIONS

USED ON NUMBERS

GENERAL NOTES:

1. ALL FERROUS PARTS ARE HOT DIP GALVANIZED PER ASTM A-123.
2. ALL FERROUS FASTNERS ARE HOT DIP GALVANIZED PER ASTM A-153.
3. ALL BALL AND SOCKET FITTINGS TO FIT ANSI CLASS 52-3 AND 52-5.
4. ALL COTTER KEYS ARE HUMPBACK STAINLESS STEEL (TYPE 304).

DRAWING AND DESIGN PROPERTY OF LINDSEY MFG. CO. UNAUTHORIZED MANUFACTURE OR REPRODUCTION IN WHOLE OR PART PROHIBITED.

ULT. STRENGTH 25,000 LBS. | REQ. 18,000

INNOVATIONS IN TRANSMISSION AND DISTRIBUTION

LINDSEY MANUFACTURING COMPANY

TITLE: 44-115KV SINGLE STRING SUSPENSION

TOLERANCES UNLESS OTHERWISE NOTED	FRACTIONS	DECIMALS	ANGLES
CAST			
FORGE			
MACHINE			
FABRICATION			

WEIGHT: ASMB— | RAW | FIN.

MATERIAL: SEE CHART | FINISH: SEE NOTES

NOTE! DO NOT SCALE DRAWING. BREAK ALL SHARP EDGES

APP. MC 10-23-86 | CHK. | DRG. KCS 10-23-86

SCALE: NONE | NUMBER: TYPE SAA

LAST REVISION: NO. B, DATE 10-23-86 | DRAWING-NUMBER: R-3053

BISHOP GRAPHICS/ACCUPRESS REORDER NO. A30722

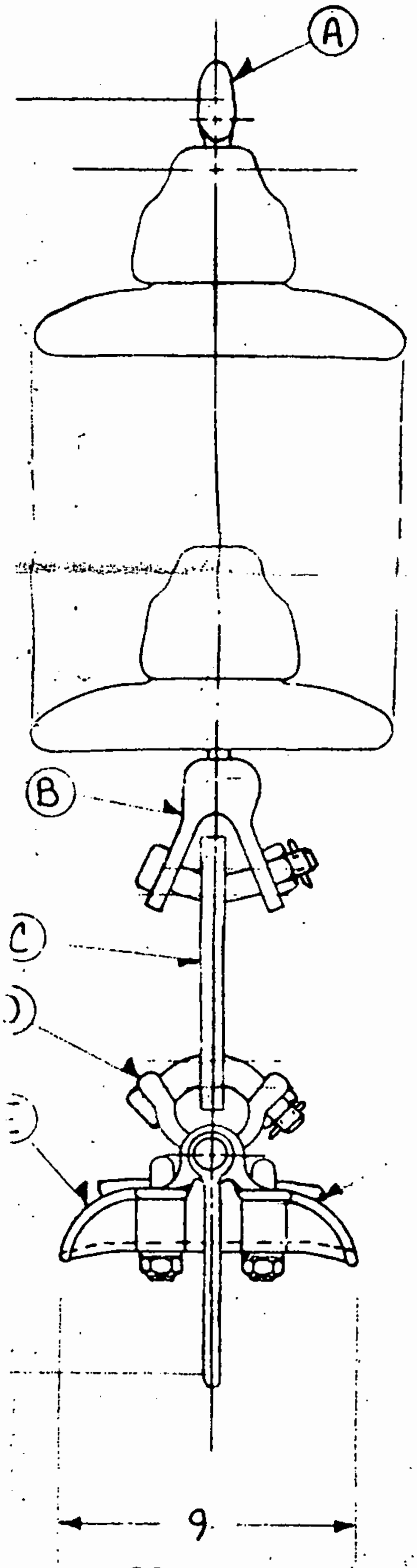
500-82-21

DRAWING NUMBER 60282

LIST OF MATERIAL

3001	ITEM	PART NO.	MATERIAL	DESCRIPTION
1	A	78420-2000	F.S.	HOOK
1	B	92802-2000	M.I.	SOCKET Y-CLEVIS
1	C	99844-4001	STL.	YOKE PLATE
2	D	93885-3003	M.I.	Y-CLEVIS EYE
2	E	87144-3006	ALUM.	SUSPENSION CLAMP
2	F	88017-2000	F.S.	CHAIN SHACKLE

SHIP UNASSEMBLED



ITEM	WEIGHT#	ULT. STR.#	A.S.T.M.
A	1.7 #	30,000#	A-576
B	2.3 #	30,000#	A-47
C	13.9 #	30,000#	A-283
D	2.2 #	25,000 #	A-47
E	5.1 #	25,000#	B-108
F	1.3 #	10,000 #	A-576

TYPE 2SJ

- CLAMP SUITABLE FOR
1.00 TO 1.47 DIA. CONDUCTOR.

697677

PACIFIC GAS & ELECTRIC

DATE	BY	DATE	BY
12-15-78	DRAFTSMAN		MFG. ENG.
12-18-78	CHECKER		TECH. DIRECTOR
12-18-78	CHIEF DRAFTSMAN		PATENT ATTORNEY
12-18-78	DEVELOP. ENG.		CHIEF ENG.

OHIO BRASS
MANSFIELD, OHIO

115 KV JUMPER ASSEMBLY TYPE 2SJ

M & T SALES	4	
VALVE SALES	83	
* P. U. SALES		
PURCHASING		
√ PRODUCTION		√

DRAWING NO. 60282
FILE 30-C SCALE

EXHIBIT E-2

Electric Line Notification

Notification # : 100317904
PM Order # :

Notification Details

Date Reported	: 09/01/2000 (15:11:11)	*Reported By*	: [redacted]		
Desired Start	:	*Priority*	: 5	5 24 months	
Required End	:	*Planner Group*	: TLE	Bellota Line	
Element (object)	: Hardware - DE	*Work Center*	: 11692	ET Line - Metcalf	
KDI (damage)	: Rusted	*Equip Impact*	: H	High Impact	
Cause	:				

Functional Location and Equipment Structure

Line #	: ETL.5463	20185 PITTSBURG-SAN MATEO
County	: ETL.5463.TOWR	20185 PITTSBURG-SAN MATEO-TOWER
Asset Type	:	
Equipment	: 40870242	044/174 LATTICE STEEL TOWER

Line Data - ETL.5463

Insulation Volt :
Operation Volt :
Structures :
Owner :
Agency :

Equipment Data - 40870242

Longitude :
Latitude :
Framing Config :
Accessibilty :
Property Rights :
UnderBuilt :

Description / Comments : PITT-S.MATEO #1 46/189 HARDWARE/RUST

05/22/2001 15:47:23 WM Conversion (WMCONV) Phone [redacted]
[redacted] 10.23.2000 15:12:14 TOP MIDDLE BOTTOM
05.09.2001 10:36:33 "C" hooks & suspension plates mild rust and wear.
02/06/2002 15:19:55 [redacted] Phone [redacted]
Comments continued on next page ....

Additional Information

Accessibility
[ ] Foot Only
[ ] Light Eqp (crew cabs,pickups)
[ ] Medium Eqp (aerial lifts,line trucks)
[ ] Heavy Eqp (cranes,tractors)

[ ] Hot Work
[ ] ISO Clearance Required
[ ] Clearance Required - Non ISO
[ ] Vegetation Work
[ ] Capital
[ ] Expense
[ ] ISO Scheduled

Inspection Type(s)
[X] Aerial Inspection
[ ] Ground Inspection
[ ] Climbing Inspection
[ ] Non-Routine Inspection

Completion Activities

Activity	*Quantity*
[ ] Adjusted	___
[X] Assessed	000
[ ] Cleaned	___
[ ] Installed	___
[ ] Located	___
[ ] Notified Third Party	___
[ ] Patrol Air	___
[ ] Patrol Ground	___
[ ] Patrol Infrared	___
[ ] Pole Top Extended	___
[ ] Removed	___
[ ] Repaired	___
[ ] Replaced	___
[ ] Stubbed	___
[ ] Tested	___
[ ] Treated	___
[ ] Trimmed	___
[ ] Other	___
Estimated Hours:	___

Completion Comments

Comp By: ___________________ *Date* __/__/__

____

Electric Line Notification

Notification # : 100317904
PM Order # :

Comments (continued)

8/30/2001 CONDITION CHECKED.
06/24/2003 09:21:29 [redacted] Phone [redacted]
FOUND COMPLETE UPON ARRIVAL BY [redacted]

EXHIBIT E-3

Electric Line Notification

Notification # : 100771136 Page 1
PM Order # :

Notification Details

Date Reported	: 08/15/2002 (06:49:19)	*Reported By*	: [redacted]	
Desired Start	: 12/03/2006	*Priority*	: 5	5 24 months
Required End	: 12/03/2007	*Planner Group*	: TLJ	Concord
Element (object)	: Hardware - DE	*Work Center*	: 11693	T- Line Concord
KDI (damage)	: Rusted	*Equip Impact*	: M	Medium Impact
Cause	:			

Functional Location and Equipment Structure

Line # : ETL.4980 20069 LAS POSITAS-NEWARK
County :
Asset Type :
Equipment :

Line Data - ETL.4980		**Equipment Data -**	
Insulation Volt	:	*Longitude*	:
Operation Volt	:	*Latitude*	:
Structures	:	*Framing Config*	:
Owner	:	*Accessibilty*	:
Agency	:	*Property Rights*	:
		UnderBuilt	:

Description / Comments : 102492800 LAS POSITAS-NEWARK RUSTY HARDW

08/15/2002 07:06:32 [redacted] Phone [redacted]
MONITOR ENTIRE LINE FOR RUSTY HARDWARE AND WORN C-HOOKS
12/03/2005 16:44:24 [redacted] Phone [redacted]
Changed to Priority 6 to comply with priority 5 backlog list.
11/05/2006 14:36:18 [redacted] Phone [redacted]
Comments continued on next page ....

Additional Information

Accessibility
[ ] Foot Only
[ ] Light Eqp (crew cabs,pickups)
[ ] Medium Eqp (aerial lifts,line trucks)
[ ] Heavy Eqp (cranes,tractors)

[ ] Hot Work
[ ] ISO Clearance Required
[ ] Clearance Required - Non ISO
[ ] Vegetation Work
[ ] Capital
[X] Expense
[ ] ISO Scheduled

Inspection Type(s)
[ ] Aerial Inspection
[ ] Ground Inspection
[ ] Climbing Inspection
[ ] Non-Routine Inspection

Completion Activities

Activity	*Quantity*
[ ] Adjusted	___
[ ] Assessed	___
[ ] Cleaned	___
[ ] Installed	___
[ ] Located	___
[ ] Notified Third Party	___
[ ] Patrol Air	___
[ ] Patrol Ground	___
[ ] Patrol Infrared	___
[ ] Pole Top Extended	___
[ ] Removed	___
[ ] Repaired	___
[ ] Replaced	___
[ ] Stubbed	___
[ ] Tested	___
[ ] Treated	___
[ ] Trimmed	___
[ ] Other	___
Estimated Hours:	___

Completion Comments

Comp By: ____________________ *Date* __/__/__

____

Electric Line Notification

Comments (continued)

Added User Status - When EL was created it was not assigned a User Status Code
08/22/2007 12:50:25 [redacted] Phone [redacted]
DATA QUALITY CLEANUP:MOVED TO MAIN GROUP CENTER 11823 TO11692

EXHIBIT E-4

From: [redacted]
Sent: Thursday, January 29, 2004 3:24 PM
To: [redacted]
Cc: [redacted]
Subject: Ball-Hook Failure Analysis TES Report No. 413.62-04.5

[redacted]:

A fractured ball-hook used to attach the insulator string directly to the tower pad was submitted for failure analysis. Of particular interest was whether environmental or ageing factors such as fatigue or corrosion had contributed to the failure.

A visual examination was performed of the hook and fracture surface. The absence of fatigue beach-marks or corrosion on the fracture surface indicates that a single overload event caused the failure. Gross distortion of the hook throat opening, flaking of the galvanize coating, and secondary cracking along the inside-back of the hook indicate that the loading event acted to pry open the hook, producing excessive bending stresses in the hook body that resulted in fracture. Evidence of normal wear, with no significant section loss, was seen at the throat bend and along the inside of the throat below the tip; no evidence of damage was evident on the outer surfaces of the hook.

In summary, the hook failure was the result of a single overload event that produced excessive bending stresses in the hook body and caused it to fracture. No evidence of environmental or ageing related degradation was found on the hook.

[redacted]

Pacific Gas and Electric Company
[redacted]
Consulting Metallurgist
Technical and Ecological Services Department
3400 Crow Canyon Road, San Ramon, CA 94583
Phone: [redacted] or [redacted] *Pager:* [redacted]
TES 24-Hr. Service Line: [redacted] or [redacted]
TES Intranet Web Site: http://tes

EXHIBIT E-5

Electric Line Notification

Notification # : **101441414**
PM Order # : **40421580**

Notification Details

Date Reported	: 08/24/2004 (09:47:26)	*Reported By*	: [redacted]	
Desired Start	: 02/20/2005	*Priority*	: 4	4 6 - 12 months
Required End	: 08/19/2005	*Planner Group*	: TLI	Metcalf Line
Element (object)	: Pull-off plate - Do Not Use	*Work Center*	: 118230LD	TLine Tower Constru
KDI (damage)	: Worn - Do Not Use	*Equip Impact*	: M	Medium Impact

Functional Location and Equipment Structure

Line #	: ETL.3320	10265 PITTSBURG-MARTINEZ #1
County	: ETL.3320.TOWR	10265 PITTSBURG-MARTINEZ #1-TOWER
Asset Type	:	
Equipment	: 40804822	005/027 LATTICE STEEL TOWER

Line Data - ETL.3320

Insulation Volt :
Operation Volt :
Structures :
Owner :
Agency :

Equipment Data - 40804822

Longitude :
Latitude :
Framing Config :
Accessibilty :
Property Rights :
UnderBuilt :

Description / Comments : PITT-MARTINEZ #1 5/27 REPL. WORKING EYES

08/24/2004 09:48:31 [redacted] Phone [redacted]
REPLACE WORN WORKING EYE PLATES ON TOWER ARM.
04/08/2005 11:05:30 [redacted] Phone [redacted]
Tower Dept completed this work on 9/14/2004.

Additional Information

Accessibility
[ ] Foot Only
[ ] Light Eqp (crew cabs,pickups)
[ ] Medium Eqp (aerial lifts,line trucks)
[ ] Heavy Eqp (cranes,tractors)

[ ] Hot Work
[ ] ISO Clearance Required
[ ] Clearance Required - Non ISO
[ ] Vegetation Work
[ ] Capital
[ ] Expense
[ ] ISO Scheduled

Inspection Type(s)
[ ] Aerial Inspection
[ ] Ground Inspection
[ ] Climbing Inspection
[ ] Non-Routine Inspection

Completion Activities

Activity	*Quantity*
[ ] Adjusted	___
[ ] Assessed	___
[ ] Cleaned	___
[ ] Installed	___
[ ] Located	___
[ ] Notified Third Party	___
[ ] Patrol Air	___
[ ] Patrol Ground	___
[ ] Patrol Infrared	___
[ ] Pole Top Extended	___
[ ] Removed	___
[ ] Repaired	___
[ ] Replaced	___
[ ] Stubbed	___
[ ] Tested	___
[ ] Treated	___
[ ] Trimmed	___
[ ] Other	___
Estimated Hours:	001

Completion Comments *Comp By:* *Date: 09/14/04*

____

____

EXHIBIT E-6

Electric Line Notification

Notification # : 101580505
PM Order # : 30429045

Notification Details

Date Reported	: 09/21/2004 (13:39:35)	*Reported By*	: [redacted]		
Desired Start	: 10/21/2004	*Priority*	: 3	3	1 - 6 months
Required End	: 11/30/2006	*Planner Group*	: TLI	Metcalf Line	
Element (object)	: Insul. - Bell	*Work Center*	: 11692	ET Line - Metcalf	
KDI (damage)	: Contaminated	*Equip Impact*	: M	Medium Impact	
Cause	:				

Functional Location and Equipment Structure

Line #	: ETL.7212	60424 SNEATH LANE-HALF MOON BAY
County	: ETL.7212.POLE	60424 SNEATH LANE-HALF MOON BAY-HALF MOO
Asset Type	: ETL.7212.POLE.WOOD	60424 SNEATH LANE-HALF MOON BAY-HALF MOO
Equipment	: 40656240	?004/003 SINGLE WOOD POLE

Line Data - ETL.7212

Insulation Volt :
Operation Volt :
Structures :
Owner :
Agency :

Equipment Data - 40656240

Longitude :
Latitude :
Framing Config :
Accessibilty :
Property Rights :
UnderBuilt :

Description / Comments : JEFFERSON-MARTIN 4/3 REPL 2 POLES

12/29/2004 13:39:28 [redacted] Phone [redacted]
WORN C-HOOKS, HARDWARE STELL ARM 2 POLE
02/25/2005 09:02:18 [redacted] Phone [redacted]
delayed until road work is done. permitting will delay road work until summer

Comments continued on next page ....

Additional Information

Accessibility
[ ] Foot Only
[ ] Light Eqp (crew cabs,pickups)
[ ] Medium Eqp (aerial lifts,line trucks)
[ ] Heavy Eqp (cranes,tractors)

[ ] Hot Work
[ ] ISO Clearance Required
[ ] Clearance Required - Non ISO
[ ] Vegetation Work
[X] Capital
[ ] Expense
[ ] ISO Scheduled

Inspection Type(s)
[ ] Aerial Inspection
[ ] Ground Inspection
[ ] Climbing Inspection
[ ] Non-Routine Inspection

Completion Activities

Activity	*Quantity*
[ ] Adjusted	___
[ ] Assessed	___
[ ] Cleaned	___
[ ] Installed	___
[ ] Located	___
[ ] Notified Third Party	___
[ ] Patrol Air	___
[ ] Patrol Ground	___
[ ] Patrol Infrared	___
[ ] Pole Top Extended	___
[ ] Removed	___
[ ] Repaired	___
[X] Replaced	003
[ ] Stubbed	___
[ ] Tested	___
[ ] Treated	___
[ ] Trimmed	___
[ ] Other	___
Estimated Hours:	024

Completion Comments

Comp By: [redacted] *Date: 04/28/06*

___

Electric Line Notification

Notification # : 101580505
PM Order # : 30429045

Comments (continued)

08/15/2005 12:19:58 [redacted] Phone [redacted]
PER [redacted] JOB IS IN ESTIMATING
09/29/2005 06:36:43 [redacted] Phone [redacted]
job is out of estimating & the access has been cleared. job will be done by mid november
10/04/2005 09:09:27 [redacted] Phone [redacted]
PER [redacted] C-HOOKS ARE ABOUT FIFTY PERCENT.
11-02-2005 10:21:57 [redacted] (ETM) [redacted] Phone [redacted]
This job is still in engineering. We will not be able to get a clearance on this line for about a year due to the Jefferson Martin Project. Moved due date out one year.
11-02-2005 10:27:40 [redacted] (ETM) [redacted] Phone [redacted]
Correction, this tag will be done as a pole replacement on PM 30429045. PM not released yet.
05/01/2006 13:34:29 [redacted] Phone [redacted]
RUSTY C-HOOKS REPLACED WITH STRUCTURE

EXHIBIT E-7

To: [redacted]
Cc: [redacted]
From: [redacted] (ET)
Sent: Fri 6/24/2011 4:27:54 PM (UTC-07:00)
Subject: Re: Jefferson - Hillsdale

And I'm sure we may have a few more out there on this section. I'll work with [redacted] to change this one out and inspect the towers in series next to this one. If needed, we'll change out those too with all new hardware and insulators.

[redacted]

----- Original Message -----
From: [redacted]
Sent: Friday, June 24, 2011 04:22 PM
To: [redacted] (ET)
Cc: [redacted]
Subject: FW: Jefferson - Hillsdale

[redacted],

Looking at the photo of the hanger plate, I would recommend changing it out to a new plate. It appears that there is a groove cutting into the plate probably caused by years of rubbing between the c-hook and the plate. You might want to discuss with [redacted] too.

[redacted]

-----Original Message-----
From: [redacted] (ET)
Sent: Thursday, June 23, 2011 12:02 PM
To: [redacted]
Cc: [redacted]
Subject: Jefferson - Hillsdale

[redacted]
We had a notification to change hardware on the Jefferson - Hillsdale Tower 10/65.

We did not have a towerman available to change out the attachment flange (frogplate) so we went ahead and changed out the insulators and all associated hardware.

The crew took a photo of the flange (attached) and we'd like to get your recommendation on moving forward with changing out the flange on this tower and others on this line.

Thanks

[redacted]

EXHIBIT E-8

Corrective Work Form Electric Transmission Line

BRIGHTON BELLOTA 061/411 INSLTR HRDWR RP

LC # 105398894

Priority E - Schd Compl Yr 0

Work Type 532 - 93K_Insulator Replacement - Steel

Line Name 20011 BRIGHTON-BELLOTA

Functional Location ETL.4420.INSL - 20011 BRIGHTON-BELLOTA-INSULATOR

Equipment 40621564 - 061/411 CERAMIC INSULATOR

Structure ID 061/411

Main Work Center VICTOR - Victor

Required End Date 2/28/2012

Planner Group TLP - ET Poles

Order # 30871493

Voltage 230 KV

Wood ☐ **Steel** ☐

Latitude 38.117696

Longitude -121.086008

Bird report event log

Bird Incident #

Facility		Damage		Activity	
IH02	Hardware - Susp.	**EL08**	Clearance (ft/in)	**REPL**	Replaced

Street

Cross Street

Division ST

City

Zip 00000

County 039 - San Joaquin Co

Crew Size

Estimated Labor Hours

Reported by [redacted]

Date Found 8/10/2011

Completed By

Date

Reviewed By

Date

Actual Labor Hours

Signature

I verify that all maintenance on this notification is completed

Field Notes

Long Text

08/15/2011 11:16:10 [redacted] Phone [redacted]

REPLACE INSULATORS AND COLD END HARDWARE DUE TO C HOOK COCKED IN BELL

(THIS COULD BE DUE TO A BAD INSTALLATION OR A WORN C HOOK).

09/01/2011 06:58:27 [redacted] Phone [redacted]

COMPLETED 08/31/2011 [redacted] TOTAL WORK HOURS 13.50

09/06/2011 09:10:58 [redacted] Phone [redacted]

30871493 - dist. copies to [redacted]

12/05/2011 09:16:58 [redacted] Phone [redacted]

HCP REVIEW: 30871493/ 105406263

LOCATION: BRIGHTON BELLOTA 061/411 INSLTR

LAT/LON PER GIS: 38.117490, -121.085894

NO HCP ISSUES INDICATED IN GIS AT THIS IMMEDIATE LOCATION. PER THE AERIAL PHOTOS ON GOOGLE EARTH DATED 6/16/11 THE IMMEDIATE LOCATION IS AG LAND/ ROW CROPS. THE TOWER IS IN THE AG FIELD. ALL WORK IS OVERHEAD NON GROUND DISTURBING WORK.

GIS INDICATES CALIFORNIA TIGER SALAMANDERS (CNDDB 1974) & VERNAL POOLS IN THE NATURAL VEG SURROUNDING THE AREA. THE CREW MUST STAY ALONG THE ROADS AND IN THE AG FIELDS/ ROW CROPS. IF THIS IS NOT POSSIBLE HCP MUST BE CONTACTED. IF ANY SENSITIVE SPECIES ARE SEEN ALL CONSTRUCTION MUST STOP AND A BIOLOGIST MUST BE CONTACTED.

PER NOTES ABOVE WORK WAS COMPLETED BEFORE HCP REVIEW.

EXHIBIT E-9

Corrective Work Form Electric Transmission Line

MARTIN-MILLBRAE #1 2/19 c hooks rusty

LC #	105413039
Priority	F - Schd Compl Yr 1+
Work Type	628 - ICS-Maintain Steel Strs > 60kV

Line Name	10149 MARTIN-MILLBRAE #1		
Functional Location	ETL.2230.TOWR - 10149 MARTIN-MILLBRAE #1-TOWER		
Equipment	40594895 - 002/019 LATTICE STEEL TOWER		
Structure ID	002/019		
Main Work Center	METCALF - Metcalf	**Required End Date**	9/1/2012
Planner Group	TLN - ET Line	**Order #**	
Voltage	115 KV	**Wood** ☐	**Steel** ☐
Latitude	37.66856	**Longitude**	-122.40663
Bird report event log		**Bird Incident #**	

Facility		**Damage**		**Activity**	
CF03	Conductor	**CH05**	Rusted	**REPA**	Repaired

Street	NEAR AIRPORT BL. AND SISTER CITIES UP H
Cross Street	
Division	SJ
City	S SAN FRANCISCO Zip 00000
County	041 - San Mateo Coun

Crew Size

Estimated Labor Hours

Reported by [redacted] **Date Found** 8/23/2011

Completed By **Date**

Reviewed By **Date**

Actual Labor Hours

Signature

I verify that all maintenance on this notification is completed

Field Notes

Long Text

08/30/2011 07:40:50 [redacted] Phone [redacted]

C hooks rusty and worn

09/06/2012 10:26:50 [redacted] Phone [redacted]

Reassess notification no -000106193319

09/26/2012 07:31:01 [redacted] Phone [redacted]

Per [redacted] on 9/25/12 - rust/wear to be checked during next inspection cycle. close tag.

EXHIBIT E-10

Corrective Work Form Electric Transmission Line

HUMBOLDT BRIDGEVILLE 109/0 PLATES SUSP

LC #	110616684
Priority	B - Urgt Compliance
Work Type	630 - ICW-Maintain Wood Strs > 60kV

Line Name	10103 HUMBOLDT-BRIDGEVILLE		
Functional Location	ETL.1810.POLE.WDPS - 10103 HUMBOLDT-BRIDGEVILLE-WO		
Equipment	40598288 - 109/000 WOOD POLE STRUCTURE		
Structure ID	109/000		
Main Work Center	EUREKA - Eureka	**Required End Date**	11/30/2015
Planner Group	TLP - ET Poles	**Order #**	42463046
Voltage	115 KV	**Wood** ☐	**Steel** ☐
Latitude	40.754166	**Longitude**	-123.989166
Bird report event log		**Bird Incident #**	

Facility		**Damage**		**Activity**	
CRSS	Crossarm	**BROK**	Broken/Damaged	**REPA**	Repair

Status - Cond/Oper Info	**Status** - Field Ident	**Status** - Field Cond (Expo)	**Status** - Field Cond (Access)	**Status** - Other
CREW Crew Work				

Street			
Cross Street			
Division	HB		
City		Zip	00000
County	012 - Humboldt Count		

Crew Size

Estimated Labor Hours

Reported by [redacted] **Date Found** 9/1/2015

Completed By ______ **Date** ______ **Actual Labor Hours** ______

Reviewed By ______ **Date** ______

Signature ______

I verify that all maintenance on this notification is completed

Field Notes

Long Text

09/02/2015 11:07:26 PST [redacted] Phone [redacted]
PER [redacted] ON 9/15/15 CREW REPLACEED WORN OUT SUSPENSION EYE PLATES ON
STEEL CROSSARM X3

EXHIBIT E-11

Corrective Work Form Electric Transmission Line

CORDELIA INTERIM PUMP 0/5 RPL HARDWARE

LC #	111710417
Priority	E - Schd Compl Yr 0
Work Type	630 - ICW-Maintain Wood Strs > 60kV

Line Name	60218C CORDELIA INTERIM PUMPS TAP		
Functional Location	ETL.8183.POLE.WOOD - 60218C CORDELIA INTERIM PUMPS		
Equipment	40757782 - 000/005 SINGLE WOOD POLE		
Structure ID	000/005		
Main Work Center	SACTO - Sacramento	**Required End Date**	5/17/2017
Planner Group	TLN - ET Line	**Order #**	42745251
Voltage	60 KV	**Wood** ☒	**Steel** ☐
Latitude	38.219158	**Longitude**	-122.158326
Bird report event log		**Bird Incident #**	

Facility		**Damage**		**Activity**	
HRDD	Hardware-Wood	**NG**	No Good/Out of Stdrd	**REPL**	Replace

Status - Cond/Oper Info	**Status** - Field Ident	**Status** - Field Cond (Expo)	**Status** - Field Cond (Access)	**Status** - Other
INSP T-Line Inspection		**REMT** Remote / Ag / Low Pop		**CLR** Clearance Required

Street	END OF RESEVOIR LANE		
Cross Street	GREEN VALLEY RD		
Division	SA		
City	FAIRFIELD	**Zip**	00000
County	048 - Solano County		

Crew Size

Estimated Labor Hours

Reported by [redacted] **Date Found** 5/17/2016

Completed By **Date** **Actual Labor Hours**

Reviewed By **Date**

Signature

I verify that all maintenance on this notification is completed

Field Notes

Long Text

06/10/2016 14:02:21 PST [redacted] Phone [redacted]
- Voltage : 60 KV
- Structure ID : 000/005

REPLACE FAILING & WORN THROUGH "C" HOOKS AND EYE NUTS. LINE IS IDLE AND DE-ENERGIZED FROM SW 45 TO END BUT OVER ENERGIZED 12KV THAT FEEDS PUMP PLNT.

11/29/2016 10:41:44 PST [redacted] Phone [redacted]
PER [redacted], COMPLETED 11/28/16.

EXHIBIT E-12

Applied Technology Services
3400 Crow Canyon Road
San Ramon, CA 94583

Report #: 413.62-18.25
June 20, 2018

METALLURGICAL EVALUATION OF INSULATOR SUSPENSION PLATES FROM THE PARKWAY-MORAGA 230 KV LINE AT STRUCTURE 020/115

Event Date	*CAP*	*Nearest City*	*Line and Voltage*	*Structure*
28-MAR-2018	114451180	Orinda	Parkway-Moraga, 230 kV	020/115

Report Prepared for:

[redacted]
Supervisor, T-line Construction
T-Line M&C Central – Bay Maintenance

and

[redacted]
Reliability Specialist, Expert
T-Line Asset Strategy & Reliability

Prepared by:

[redacted]

[redacted]
Senior Advising Materials Engineer

Reviewed by:

[redacted]

[redacted]
Senior Materials Engineer

1.0 EXECUTIVE SUMMARY

On 13-APR-2018, six suspension plates were received at ATS for analysis of severe wear found at the insulator attachment points. Three of the plates were from the 230 kV Parkway-Moraga transmission line at structure 020/115, and three were from the Bahia-Moraga 230 kV transmission line on the opposing side of the same structure.

Based upon the observed macro- and microscopic deformation of the material, the wear was attributed to wind-driven swinging of the insulators (wind-sway). In the most severely worn plate, the thickness of the load-bearing ligament measured 0.282”, or 38% of the design value of 0.75”. Because the plates are believed to have been installed in 1946, this minimum ligament thickness was used to estimate the maximum average observed wear rate to be 0.007”/year. This wear rate was used to estimate the remaining lifetime based upon design-calculations of the ligament strength. The remaining life of the plates was conservatively calculated to be between 28 years and 25 years, depending upon the load (estimated to be between 4,000 and 5,000 lbs, respectively). This remaining life prediction is generally conservative because it is based upon the most severe wear observed, and because the calculations utilize idealized design criteria. However, it should be noted that the prediction assumes failure by a specific mode (shear tear-out), and it could become unconservative if the plates begin to experience cracking. No cracking was observed in the present microstructure. However the stress will increase as the ligaments undergo thinning due to future wear, and this may increase the susceptibility to cracking due to fretting or fatigue.

Recommendations

- Perform targeted, additional inspections at selected locations where environmental and loading conditions could be considered to be equivalent based on i) span length, ii) vertical loading, iii) spot elevation, iv) depth of crossing, and v) orientation perpendicular to the prevailing wind.

Secondary Findings

- The material from which the plates were fabricated meets the requirements of both ASTM A7-42 and ASTM A36-14.
- The wear in the plates appears to be within expectations given the material and vintage.
- No manufacturing deficiencies were identified in the material.

2.0 LIST OF APPENDICES AND ATTACHMENTS

- Appendix A: Component Testing Information Sheet (CTIS)
- Appendix B: Engineering Drawing NG3 (1946)
- Appendix C: Anamet Report 5005.5872, Tensile and Chemical Testing
- Appendix D: Engineering Drawing 3008548, R1 (2013)

3.0 INTRODUCTION

On 28-MAR-2018, three suspension plates were removed from the 230 kV Parkway-Moraga Transmission Line at structure 020/115[1] because substantial wear was observed at the insulator attachment points. On 02-APR-2018, three additional plates were removed from the opposing side of the same structure, the Bahia-Moraga 230 kV transmission line, for the same reason. The issue was submitted as CAP #114451180, and the six plates were sent to ATS for evaluation of the material quality and wear mechanism. The evaluation is intended to support a broader assessment of the integrity of similar components in other locations.

[1] Original designation was structure 48/260 of the Vaca-Dixon-Moraga Line per drawing 22857, Rev. 20 (2/16/16).

The components received at ATS on 13-APR-2018 comprised the six suspension plates shown in Fig. 1. Note that the plates from the two lines were comingled such that there was no documentation associating the individual plates with either transmission line. The accompanying CTIS indicated that the location was a ridgetop with constant high- to medium-strength winds (Appendix A). The location is illustrated in Fig. 2, where Fig. 2a shows the location of the structure and the span over Highway 24 in a map-view from ET-GIS. Fig. 2b shows the actual structure in a screen shot from the high-resolution flyover-video available through ET-GIS. The view is south-facing, with the top of structure 020/115 visible in the foreground and the base of structure 021/116 visible near the top edge of the image. Additional related background information on the location, structure, and transmission line were recovered from ET-GIS and the GIS Asset Inventory Database. These data are tabulated in Table I, and indicate that the structure and insulators were installed in 1946. This implies that the suspension plates were probably installed in 1946, and no contradictory information was discovered via discussion with T-Line Maintenance and T-Line Civil Engineering.

4.0 EVALUATION

The plates were inspected by the following methods:
- Visual Inspection
- Metallography
- Optical and Scanning Electron Microscopy (SEM)
- Mechanical Testing (Rockwell B and Tensile Testing)
- Chemistry (OES and LECO)

5.0 RESULTS

Fig. 1 shows the suspension plates as-received. The plates were tentatively grouped into two sets of three based on the extent of visible corrosion, and were numbered '1' through '6'. Based on the prevailing wind direction (westerly) and the orientation of the tower/line (north-south), it could be suggested that the more corroded plates (Fig. 3) are likely to be associated with the downwind Bahia-Moraga line, and the less corroded plates (Fig. 4) to the upwind Parkway-Moraga line. However, no supporting documentation was provided to associate the individual plates with either line.

The approximate dimensions of the individual plates are 14.5" long, 3.5" wide, and 0.64" thick. In each plate, there are six mounting-holes with diameters of 0.673", and one insulator-attachment hole with an original diameter of 1.484". These dimensions are consistent with the 1946 engineering drawing from a comparable structure supplied by T-Line Civil Engineering (Appendix B).

On all of the plates, the insulator-attachment has worn one axis of the larger holes to an average length of 1.93", decreasing the ligament below the insulator attachment from the design value of 0.75" to between 0.282" and 0.462". This is illustrated in Figs. 3 and 4, which show front- and back-side views of the six suspension plates. These images show that the wearing of the plates at the attachment point has created an obvious decrease in the distance from the elongated hole to the edge of the plate. The decrease in the thickness of that ligament is accompanied by substantial plastic deformation that gives the appearance of material 'squeezing' out (extruding) from the wear surface. Fig. 5 shows this deformation in more detail for Plates 2, 4, and 6. In that Figure, and in Fig. 6, it can be seen that the wear surfaces are largely covered with corrosion products and exhibit only localized areas of the bright metal associated with recent wear. This seems to imply that, at any given time, the actual contact area between the insulator hook and the wear surface is small, and/or that the severity of the wear process is not constant.

Fig. 7 shows the cut-map describing the locations from which sub-samples were taken for metallographic inspection. Transverse and longitudinal samples of the bulk microstructure were obtained from the locations indicated in Fig. 7b. These mounts are transverse to, and parallel to, the long-axis of the plate, respectively. Also, the microstructure beneath the wear surfaces was sampled parallel to the wear surface (Plate 6, Fig. 7a), and perpendicular to the wear surface (Plate 2, Fig. 7b).

Fig.8 shows the bulk microstructure from Plate 2 at 200x and 500x. The microstructure is comprised of dark pearlite regions in a light ferrite matrix, and is consistent with published examples of low carbon steel, e.g., grade ASTM A36.[2] The ferrite is generally polygonal (equiaxed) in both the transverse (a, c) and longitudinal (b, d) microstructures, indicating full recrystallization and little or no residual deformation (banding) from the manufacturing or rolling processes.

Images from the polished cross-section through the wear surface of Plate 6 are shown in Fig. 9. This cross-section corresponds to the section labelled 'Parallel' in Fig. 7a. The wear surface at the top of the images shows evidence of corrosion, including pitting. In addition, Fig. 9b shows clear evidence of plastic shearing of the surface. No cracks were located in the cross-section. The same section is shown in Fig. 10 after etching to reveal the microstructure. The etching reveals substantial shear deformation in the microstructure below the wear surface, including orientation and elongation of the (light) ferrite grains, distortion of the (dark) pearlite colonies, and the appearance of debris distributed throughout. It will be discussed below that the observed 'debris' is largely due to breakup of the pearlite colonies and the presence of deformation bands.[3,4,5] The deformation of the microstructure can be further illustrated by comparison of the insets from Fig. 10 to Figs. 8a and 8b. Note that the deformation in these images runs in the circumferential direction of the insulator-attachment hole, and so could be attributed to either sliding or rolling of the insulator pin (in the plane of the plate). As will be discussed below, the pattern of the deformation is consistent with the forces arising from rolling contact. This is consistent with the forces that would arise from swinging of the insulator due to line sway.

Figs. 11 and 12 show comparable views of the perpendicular cross-section from Plate 2, Fig. 7b. The polished views in Fig. 11 again show surface corrosion and plastic shear, but no cracking. Fig. 11b shows the ductile flow at the edge of the wear surface (the material that appears extruded from the wear surface in Fig. 5). This plastic deformation resulted from shear forces in the through-thickness direction (perpendicular to the plane of the plate). Fig.12 shows the distortion in the etched microstructure below the wear surface. In these images, the microstructure is similar to that observed in Fig. 10, with orientation and elongation of the (light) ferrite grains, distortion of the (dark) pearlite colonies, and the appearance of debris distributed throughout. Note that these images are at higher magnification than those in Fig. 10. The images in Fig. 12 are taken at increasing depth below the surface such that at approximately 65 mils (0.065") below the surface (Fig. 12d) the microstructure is equivalent to the bulk microstructure documented in Fig. 8c. As with Fig. 10, closer to the surface the ferrite regions appear to be littered with debris (Figs. 12a - 12c). Inspection of the etched microstructure using scanning electron microscopy (SEM) to achieve elevated magnification, Fig. 13, reveals that the pearlite colonies near the surface have been broken apart by the shear forces associated with the deformation. In these images, the

[2] B.L. Bramfitt and A.O Benscoter, Metallographer's Guide: Practices and Procedures for Irons and Steels, (ASM International, Materials Park, OH, 2002), pp. 6, 178.
[3] M. Vilotic, L. Sidjanin, D. Rajnovic, and M. Novovic, "SEM-TEM study of low carbon steel subjected to conventional and severe plastic deformation," The 16th European Microscopy Congress, Lyon, France, August 22, 2017.
[4] M.G. Maruma, C.W. Siyasiya, and W.E. Stumpf, "Effect of cold reduction and annealing temperature on texture evolution of AISI 441 ferritic stainless steel," J. S. Afr. Inst. Min. Metall., 113, (2013).
[5] E. Ahmad, et al., "Effect of cold rolling and annealing on the grain refinement of low alloy steel," 2014 IOP Conf. Ser.: Mater. Sci. Eng., 60 (2014).

regions that appear to comprise multiple, parallel lines are the pearlite colonies. Figs. 13b and 13d show examples from the bulk of the plate, away from the shearing forces at the wear surface. Those colonies are typically well formed, contiguous, and widely separated by intact ferrite grains. In contrast, near the surface (Figs. 13a and 13c), the pearlite colonies appear smaller and fragmented, with the fragments dispersed by the plastic flow of the ferrite matrix. The apparent debris littering the ferrite grains is thus attributed to the breakup of the pearlite colonies near the surface.

Tables II and III show the results of mechanical testing and chemical analysis of Plates 2, 4, and 6, with the original test report provided in Appendix C. The tensile testing was performed on sub-sized samples using a 1" gauge length due to the plate geometry. The average yield and tensile strengths are 40.2 ksi and 64.9 ksi, respectively, and the average elongation to failure is 39.0%. These meet the requirements of the current ASTM A36-14[6] and the prior specification ASTM A7-42[7]. Similarly, the chemistry results shown in Table II conform to those same standards. Hardness limits are not called out in either standard, but HRB data are provided in Table II for reference.

6.0 DISCUSSION

The data presented in the Results section show the suspension plates to have a microstructure typical of rolled plain carbon steel comparable to ASTM A36 (or the precursor ATSM A7). The microstructure is 19.8% pearlite dispersed in irregular colonies up to approximately 0.0025" in the major dimension (2.5 mils). No excessive or atypical manufacturing features were observed (inclusions, excessive stringers, etc.), and the ferrite microstructure is generally equiaxed and well annealed. The strength and composition conform to both the current specification ASTM A36-14 and the prior specification ASTM A7-42.

Representatives from T-Line Civil Engineering were unable to identify original drawings specific to this component and the related structure. There appears to be a high probability that the structure in question was built from drawing NG3 (Appendix B), however that drawing is unclear whether the grade specification for the suspension plates is ASTM A7 or 'Hi Elastic'. ASTM A7 is the precursor to ASTM A36, and the current 2013 drawings from a cage-extension project for towers on the Vaca-Lakeville line (Appendix D) specify ATSM A36 for the suspension plates. Because the tensile and chemical analyses of the plates conform to these standards, it is likely that the plates were originally manufactured in conformance with ASTM A7-42.

The wear surfaces show significant plastic deformation, both macroscopically (Fig. 5) and within the subsurface microstructure (Figs. 10 and 12). This deformation is characteristic of adhesive wear, which refers to the damage produced when surface asperities interact, and very high stresses, strains, and strain rates are generated in localized regions.[8] Adhesive wear can produce extensive extrusion of material, material transfer, plastic shearing, and pinholes.[8,9] The subsurface deformation visible in Fig. 10 is characteristic of Hertzian contact with a rolling component, where the maximum shear stresses occur

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[6] ASTM A36/A36M-14, "Standard Specification for Carbon Structural Steel," (ASTM International, West Conshohocken, PA, 2014).
[7] ASTM A7-42, "Standard Specifications for Steel for Bridges and Buildings," (ASTM International, West Conshohocken, PA, 1942).
[8] A. Ball, "The mechanisms of wear, and the performance of engineering materials," *J. S. Afr. Inst. Min. Metall.*, **86**, (1986).
[9] A.A. Maiche, "Fretting Wear Mechanisms in A216 Plain Carbon Steel," a dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy, University of California, Berkeley, Spring 2016.

below the surface at a depth that is related to the applied force, the elastic properties of the materials, and the geometry of the interface.[10]

Recalling from the Introduction that the probable installation date for these components was 1946, they may have been in service for over 70 years. The span lengths on either side of the structure (020/115) are 999.6' to 020/114 and 2,123.6' to 021/116 (per drawing #202857, Rev. 21), where the latter passes from peak-to-peak over Highway 24 at a height of approximately 500'. The area is known to be windy in the summer due to the sea breeze effect where hotter inland temperatures draw westerly breezes in from the ocean and bay. These breezes are capable of driving conductor movement in the form of wind-sway, Aeolian vibrations, conductor galloping, or wake-induced oscillation. The latter of these two phenomena can probably be excluded from consideration since conductor galloping is typically associated with asymmetric drag caused by ice formation, and since the Parkway-Moraga line is on the upwind (west) side of the structure. Under moderate wind speeds, up to approximately 20 mph, Von Karman vortex shedding will induce vertical Aeolian vibrations at frequencies depending on the Strouhal relationship[11]:

$$f = 0.185\,\frac{V(m/s)}{D(m)} = 3.256\,\frac{V(mph)}{D(in)} \tag{1}$$

In Eq. (1), V represents the wind speed and D the conductor diameter. This places the frequency in the range of 13-40 Hz for this 954 kcmil ACSR conductor. These frequencies seem too high to induce sufficient displacement amplitudes in the insulator to create the observed deformation. Also, as noted with respect to Eq. (1), the vortex-shedding forces associated with these displacements are vertical, which is not consistent with the biaxial deformation observed in the microstructures. Finally, it was reported by the T-Line M&C Foreman that there were vibration dampers on all three phases. The conclusion is that the wearing has resulted from wind-sway, or swinging of the insulators driven by windy conditions over the highway. The combined effects of this movement and the loading from the insulator and conductor, estimated at 4,000 to 5,000 lbs (discussed below), led to the observed wearing over the course of several decades. This process is inevitable, and the observed condition of the suspension plates appears to fall within normal expectations. It should be considered that the length and character of the span between structures 020/115 and 021/116, a valley crossing of 2,123.6', may have contributed to the severity of the movement.

Mechanical calculations were performed to estimate the load-to-failure as a function of the thickness of the ligament between the insulator attachment and the edge of the plate. These conservative calculations were based on design guidelines[12], assume an idealized geometry failing by shear tear out, and estimate the shear strength to be 60% of the ultimate tensile strength (UTS) per ANSI/AISC 360-16.[13] Based on Eq. (7.1) from Footnote 12, the ligament thickness at failure, L_c, is given by

$$L_c = \frac{R_n}{1.2 F_u t} \tag{2}$$

where R_n, F_u and t represent the load, tensile strength, and plate thickness, respectively. Fig. 14a shows the load-to-failure versus ligament thickness calculated using both the minimum UTS from ASTM A7-42 (60 ksi), and the average measured UTS (64.9 ksi). The load-to-failure is 13,000 lbs or 14,050 lbs,

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[10] J.T. Burwell, Jr., "Survey of Possible Wear Mechanisms," *Wear*, **1**, (1957/1958).
[11] J-L Lilien, "Power Line Aeolian Vibrations," Universite de Liege, (2013).
[12] W.T. Segui, Steel Design, (Cengage Learning, Independence, KY, 2007), Section 7.3.
[13] ANSI/AISC 360-16, Specification for Structural Steel Buildings, (American Institute of Steel Construction, Chicago, IL, 2016).

respectively, at the minimum observed ligament thickness of 0.282", and decreases linearly with decreasing ligament thickness per Eq. (2).

Based on the extent of the wear noted in Figs. 3 and 4, assuming a linear wear rate over 72 years implies a loss of approximately 0.004" to 0.007" per year. Assuming the wear rate to be 0.007"/year, the time-to-failure was calculated as a function of the applied load, R_n. The calculation used the minimum observed ligament thickness as a starting point, and estimated the time as

$$T_f = \frac{(0.282"-L_c)}{w} \tag{3}$$

where T_f and w represent the time-to-failure and the wear rate, respectively, and Lc was calculated per Eq. (2) using the minimum specified UTS from ASTM A7-42 (60 ksi). The results are illustrated in Fig. 14b, where it is shown that the remaining life decreases linearly with increasing load from approximately 35 years at 1,500 lbs to less than 5 years at 12,000 lbs. Rough calculations based upon span length, the unit weight of the 954 kcmil ACSR conductor (1.227 lbs/ft)[14], and weight of the ceramic suspension insulator (191 lbs.)[15] indicate vertical loading on the plates was in the range of 4,000 - 5,000 lbs at this structure. That loading places a conservative estimate of remaining life at 25 – 28 years. More accurate assessment of the vertical loading was not performed because the plates have already been replaced on this structure, and those calculations would not be relevant at other structures.

Several potential sources of error should be noted:

1) The dependence of wear rate on the applied load was not accounted for in the calculations because the actual current and historical loads were unknown.

2) The linear wear-rate assumption may be overly conservative (higher-than-actual wear rate) since the initial size mismatch between the attachment hole (1.5") and the insulator hook (~1") probably caused higher than average initial wear rates due to a smaller contact area in the initial geometry.

3) The linear wear rate could be invalidated if cracks due to fretting or fatigue begin to occur as the stresses increase with decreasing ligament cross-section. Note that no cracking was discovered in the present condition.

4) As noted in Table I, 36" aviation marker balls were added to the span in 1999. It's not clear what, if any, impact this may have had on the wear rate for the affected phases.

The data used to generate Fig. 14b are tabulated in Table IV for reference, however these lifetime estimates should be used with caution at other structures where the vertical loading could be different (refer to #1 above).

7.0 CONCLUSIONS

Based on the observed data, the wear in the suspension plates is within expectations. No manufacturing deficiencies were identified, and the material properties meet the requirements of both ASTM A7-42 and ASTM A36-14. The appearance of the wear surfaces and the subsurface microstructure are consistent with adhesive wear, and indicate that the relative motion of the wear surfaces can be attributed to swinging of the insulator induced by the predominant cross-breeze. The severity of the wear condition is

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[14] 954 kcmil ACSR is not currently a standard PG&E conductor, so data were taken from a manufacturer website: www.southwire.com

[15] Table 10 in PG&E Document 015014, Rev. 10, "Suspension Type Insulators," (8/15/2017).

likely to have been exacerbated at this location by the length of the span (2,123.6'), the elevation and geometry of the landscape (peak elevation of 1,100' crossing approximately 500' above Highway 24), and possibly by the addition of aviation markers (installed in 1999).

A conservative estimate of the remaining life of the plates was performed by calculating the minimum ligament thickness as a function of load, and applying a wear rate of 0.007"/year to the smallest observed ligament (0.282"). The results indicate that the remaining life decreases linearly with increasing load from approximately 35 years at 1,500 lbs to less than 5 years at 12,000 lbs. A rough estimate of the vertical loading on this structure is 4,000 - 5,000 lbs, indicating that the remaining lifetime of these plates was 28 - 25 years, respectively. It should be noted that this estimate neglects the possibility that the plates develop cracking (from fretting or fatigue) as the nominal stress increases due to ligament wear.

Additional inspections should be conducted at selected locations where environmental and loading conditions could be considered to be equivalent based on i) span length, ii) vertical loading, iii) spot elevation, iv) depth of crossing, and v) orientation perpendicular to the prevailing wind.

Figure 1: As-received photograph of six suspension plates submitted to ATS for evaluation.

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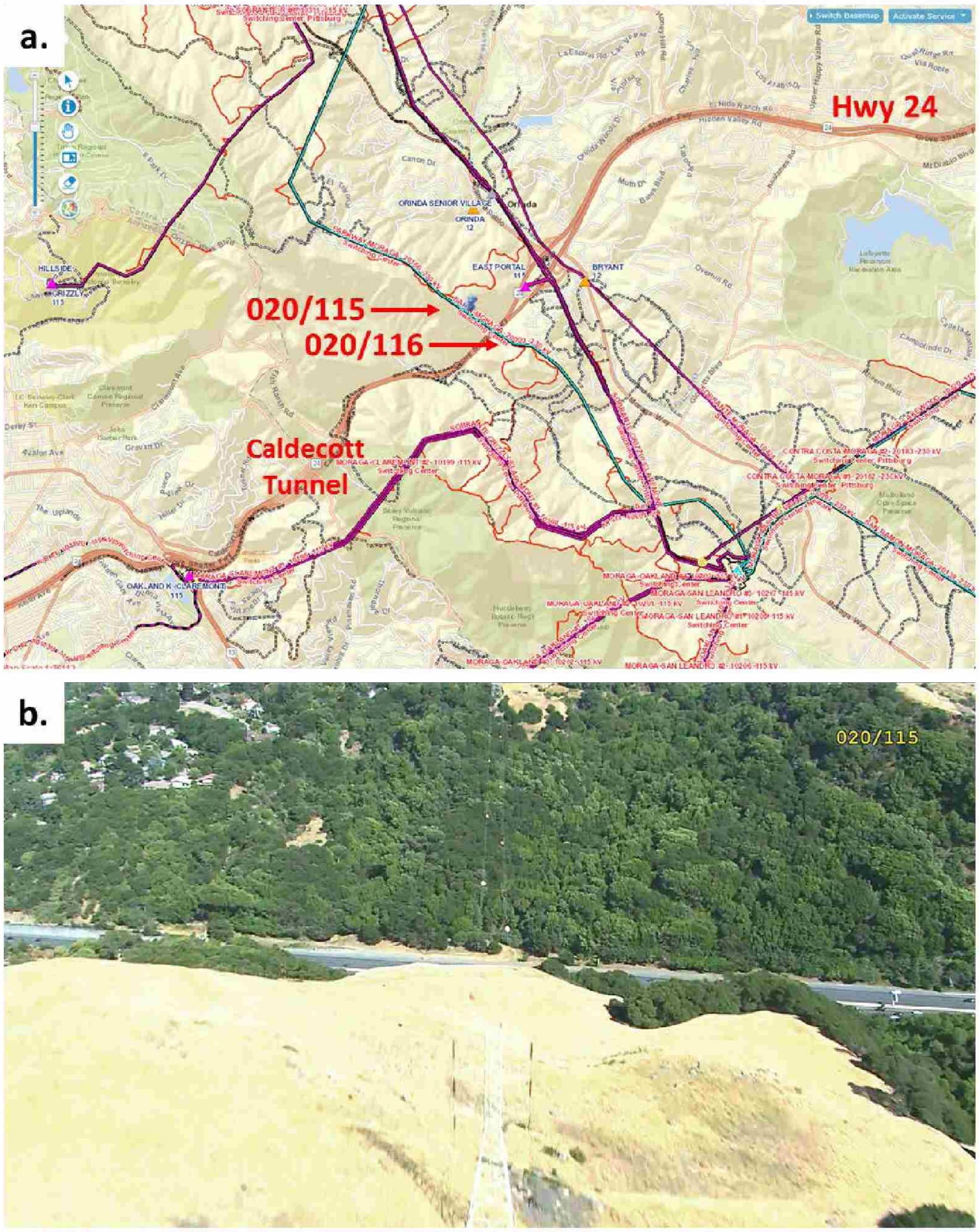

Figure 2: a) Map view of the location of structure 020/115 passing over Highway 24 slightly east of the Caldecott Tunnel, and b) screenshot from a high-resolution flyover-video (ET-GIS) showing the span over Highway 24, with 020/115 in the foreground and 021/116 in the distance.

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Table I: Background data harvested from ET-GIS.

Parkway-Moraga Suspension Plate at 020/115		
Project	Supervisor	[redacted]
	Project PM#	31385452
	CAP #	114451180
	Removed from service	3/28/2018
	Received at ATS	4/13/2018
Line	T-Line Name	Parkway-Moraga
	Line kV	230 KV
	T-Line ID_ID / SAP_FL	4460 / ETL.5930
	Conductor type	ACSR
	Conductor size	954
	Stranding	54/7
	ET Conductor Grouping	Single
	Conductor Loading Zone	Yes
	Conductor Ampacity Rating Zone	Coastal
	Normal Wind Speed	2
	Emergency wind speed	2
Structure	Structure Number	020/115
	Structure_ID / SAP_EQ_NBR	229303 / 40605469
	Tower Type	NGX
	Tower Year Installed	1946
	Footing Type	Concrete
	Tower Lightening	None
	Marker Balls Type	36" DIA. 20# Powerline Aviation Marker Ball
	Marker Balls Year Installed	1999
Insulator	Insulator Material	Ceramic
	Insulator Type	Sespension
	Insulator Year Installed	1946
	Insulator Rating	15000
Location	Latitude	37.873554
	Longitude	-122.194568
	Elevation, ft	1102
	Climate	X
	County	Contra Costa
	Raptor Concentration Zone	Yes
	Land Use	Public (NEC)
	Zip Code	94563
	Snowload	No
	Corrosion	No
	Calfire Index	N/A

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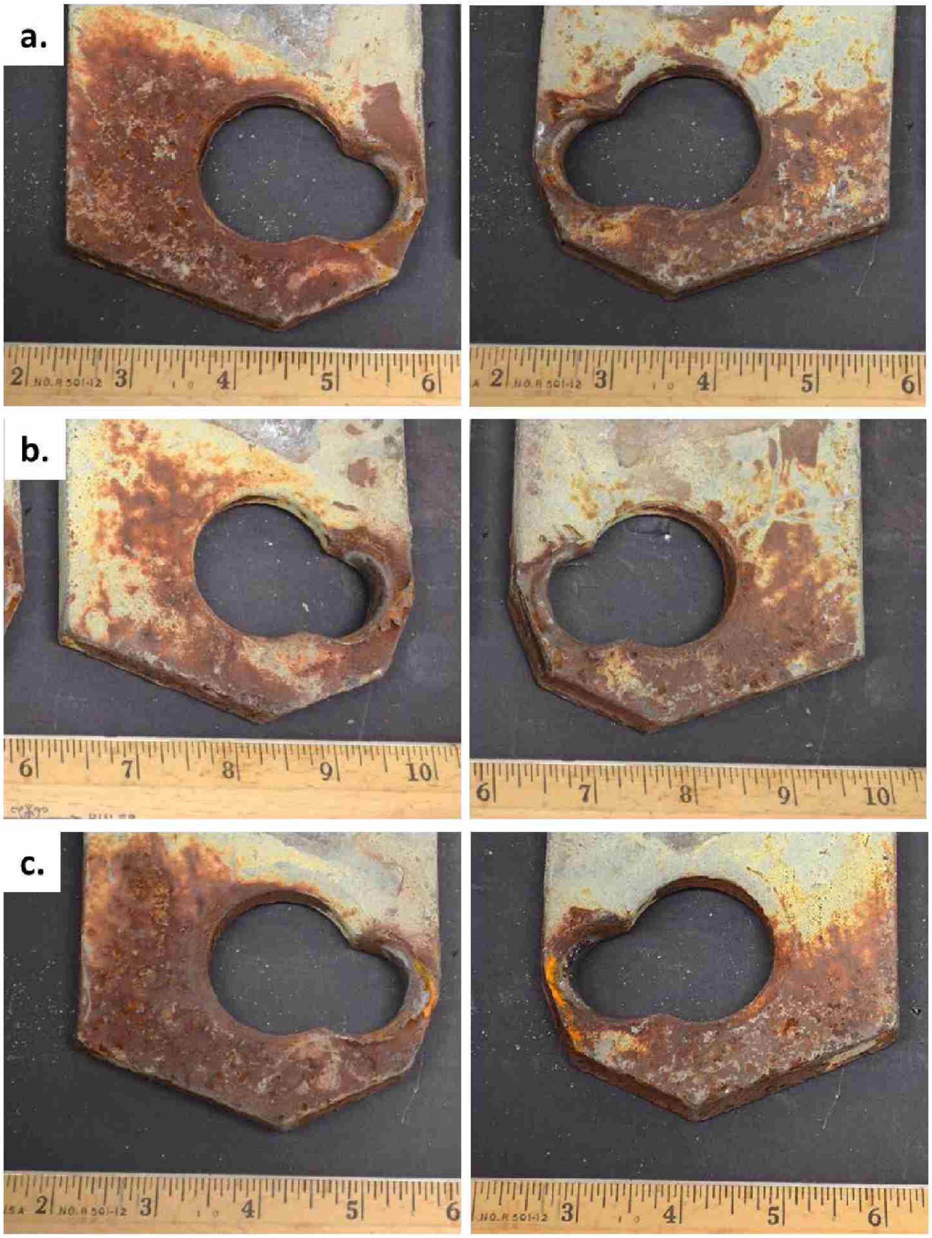

Figure 3: Front- and back-side views of the insulator attachment point for: a) Plate 1, b) Plate 2, and c) Plate 3. These three plates show more corrosion than Plates 4-6 (Fig. 4) and are likely to have come from the downwind side of the structure (the Bahia-Moraga line).

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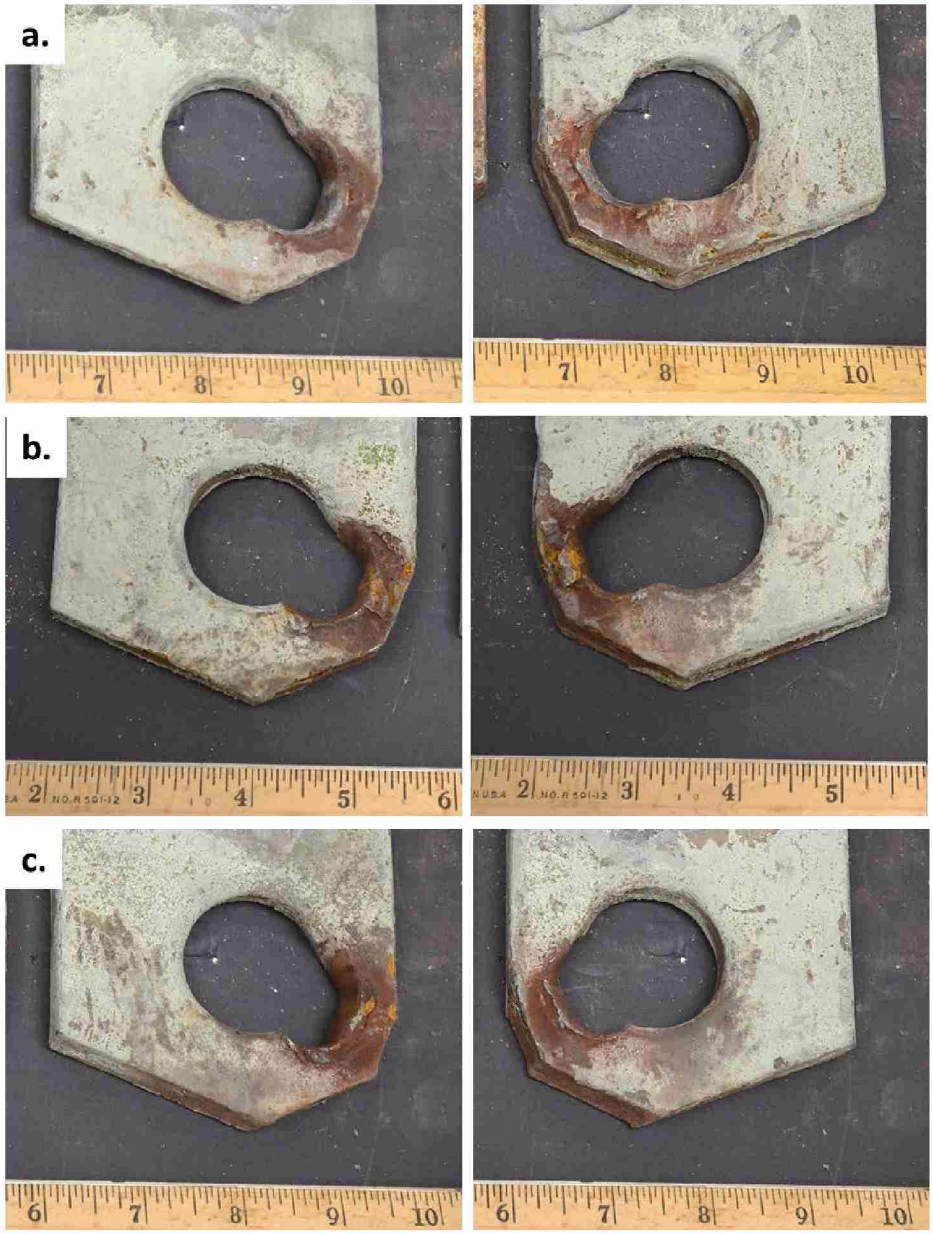

Figure 4: Front- and back-side views of the insulator attachment point for: a) Plate 4, b) Plate 5, and c) Plate 6. These three plates show less corrosion than Plates 1-3 (Fig. 3) and are likely to have come from the upwind side of the structure (the Parkway-Moraga line).

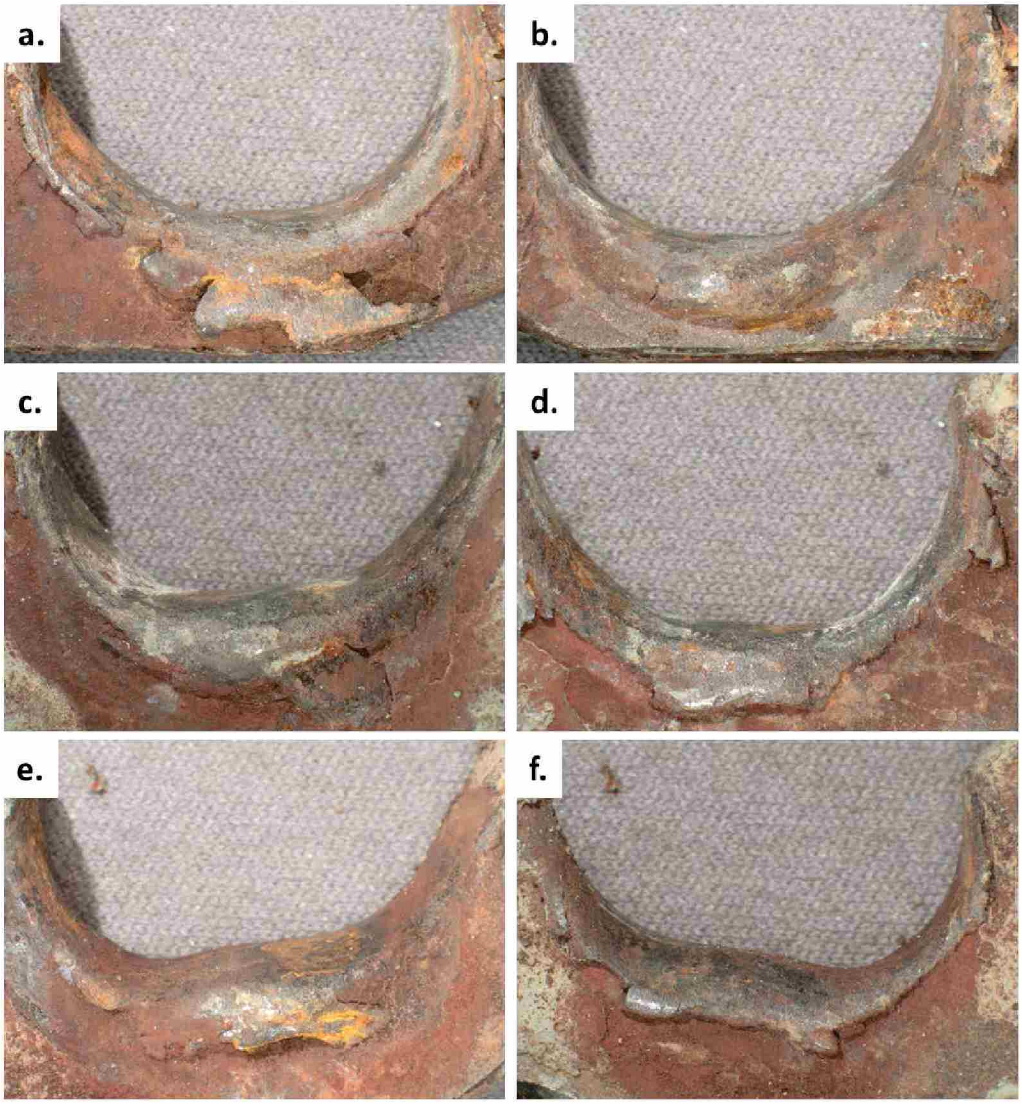

Figure 4: Close-up views of the front- and back-side of the insulator attachment point. (a, b) Plate 2, (c, d) Plate 4, (e,f) Plate 6. These views show substantial wear and plastic deformation.

Figure 6: Views of the wear surface from Plates 2, 4 and 6, showing plastic deformation and uneven wear.

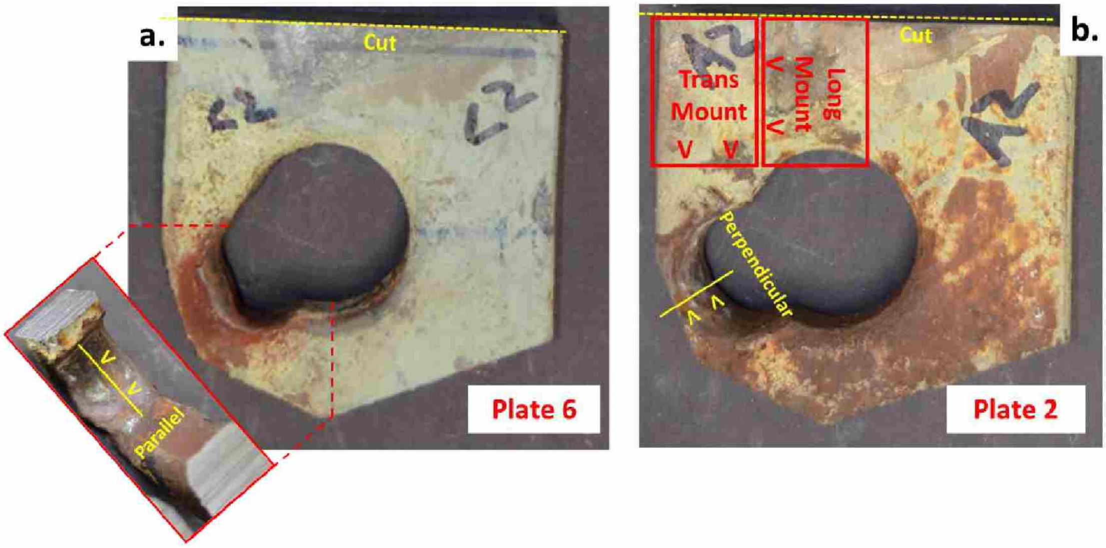

Figure 7: Cut-map showing the locations from which the metallographic sections were taken.

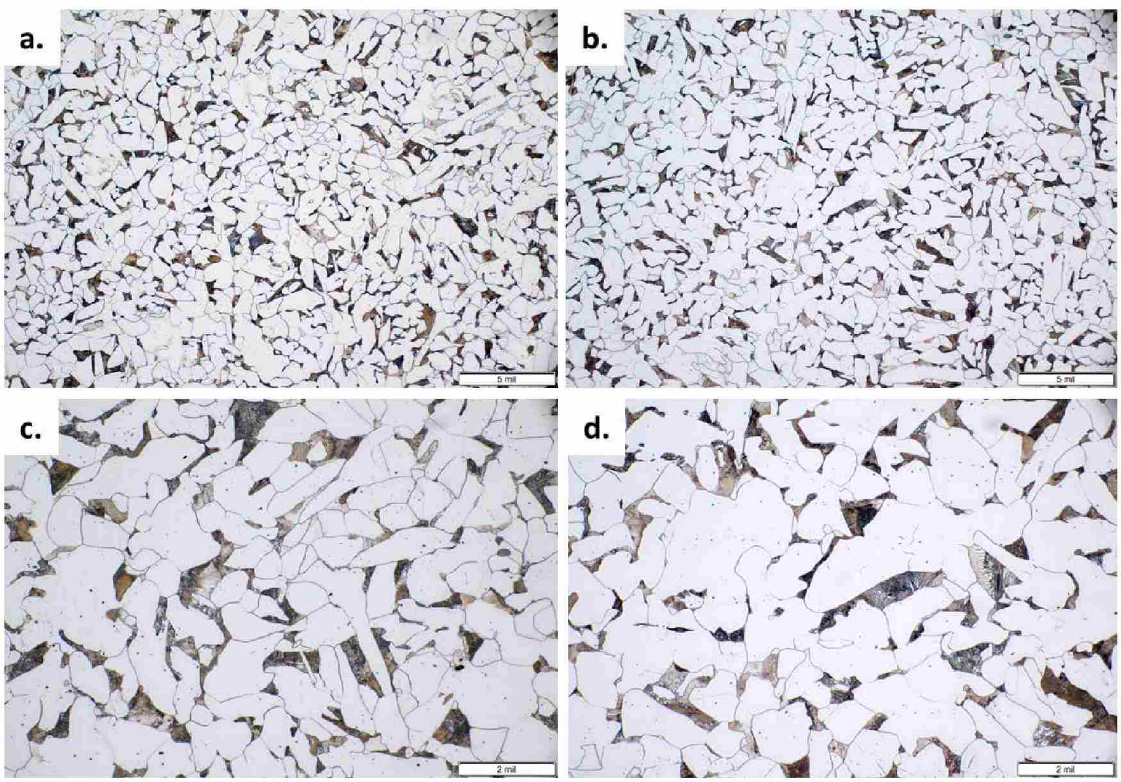

Figure 8: Metallographic cross-sections at 200x (top) and 500x (bottom), etched to reveal the microstructure. The sections were taken from the locations indicated in Fig. 7b: (a, c) 'Trans Mount', and (b, d) 'Long Mount'. The microstructures are imaged along the directions indicated by the red V's in Fig. 7b.

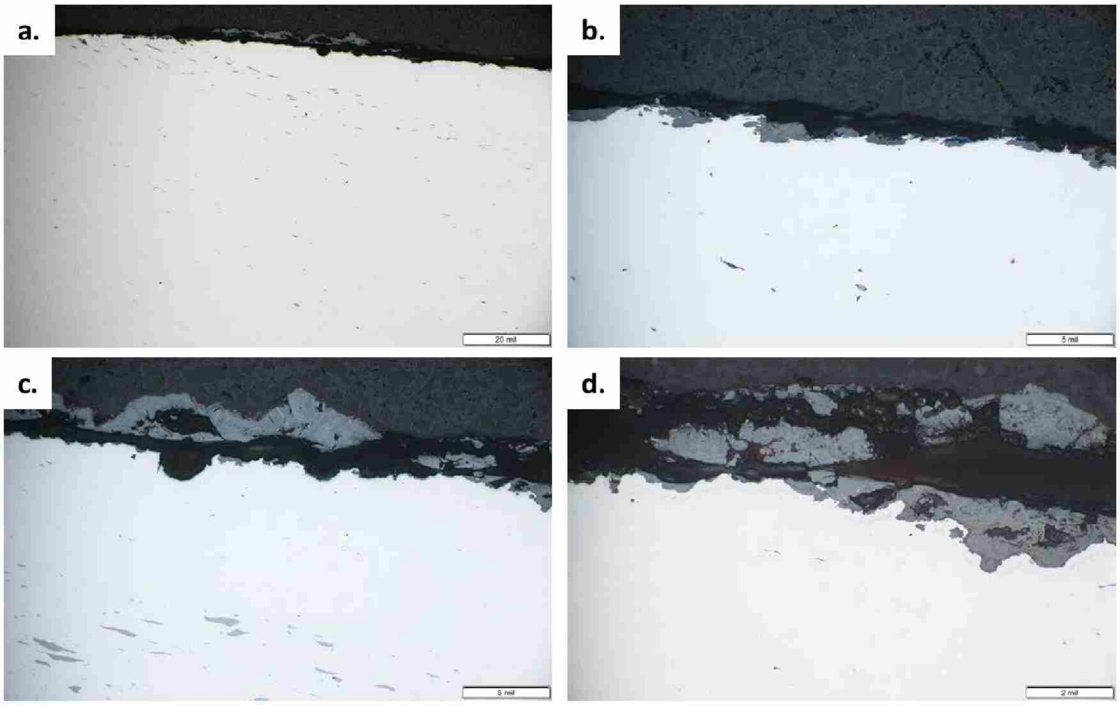

Figure 9: Polished cross-sections parallel to the wear surface from Plate 6. (a) 50x, (b, c) 200x, and (d) 500x The images show corrosion and pitting, and plastic shearing at the surface. No cracking was observed anywhere in the cross-section.

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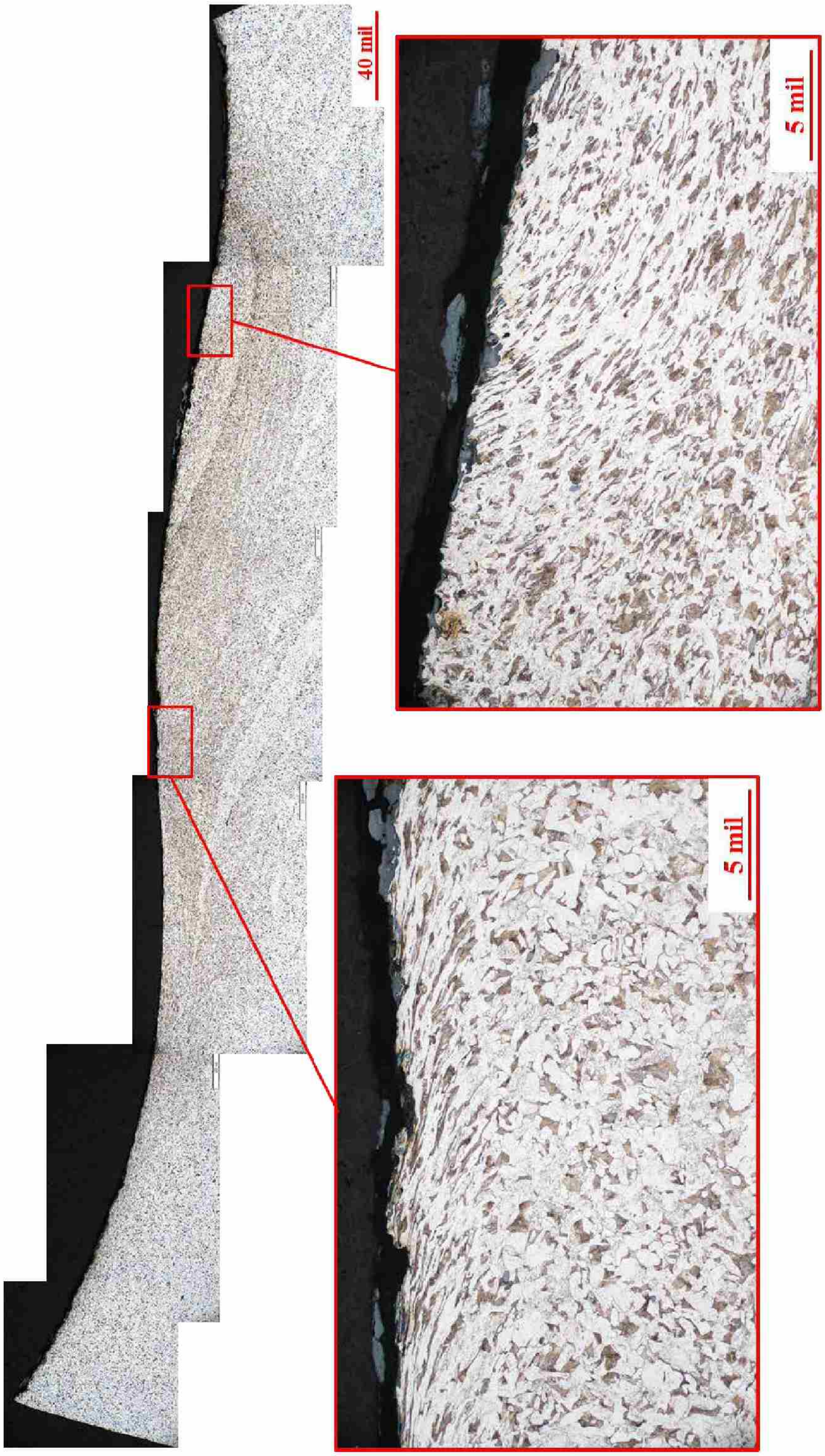

Figure 10: Etched cross-section of the wear surface shown in Fig. 9. The images show uneven wearing and shear deformation of the microstructure below the surface.

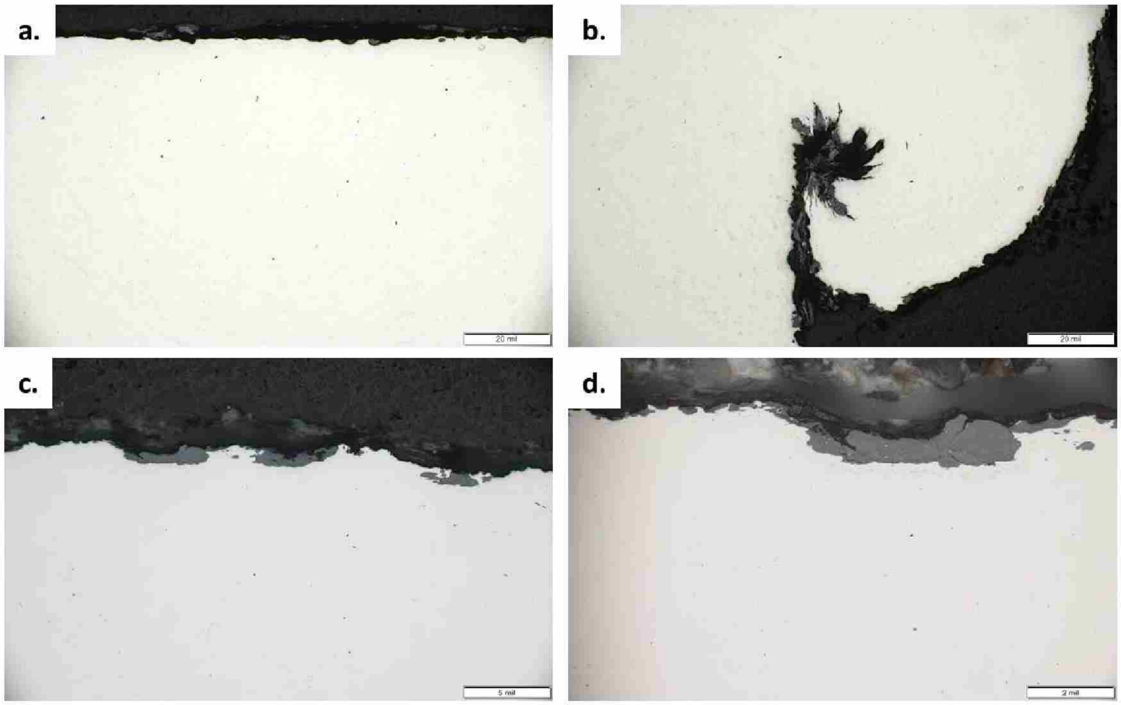

Figure 11: Polished cross-sections perpendicular to the wear surface from Plate 2. (a) 50x, (b, c) 200x, and (d) 500x The images show corrosion and pitting, and plastic shearing at the surface. No cracking was observed anywhere in the cross-section.

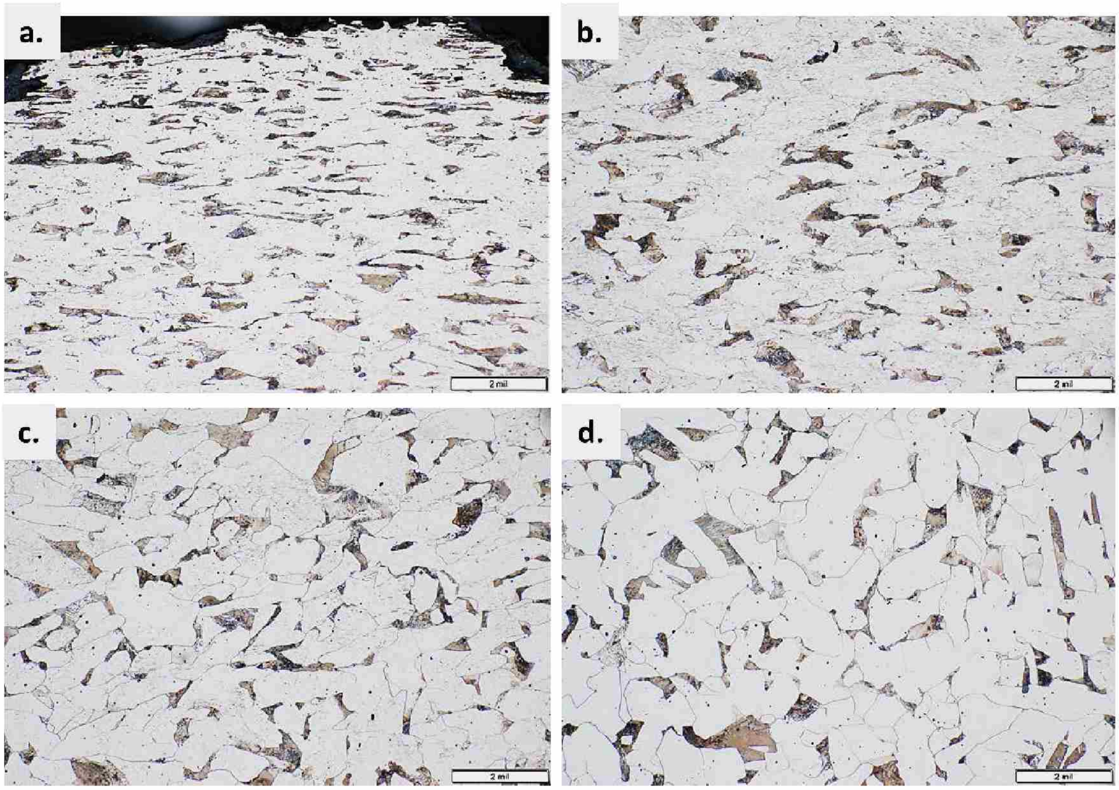

Figure 12: Polished cross-sections perpendicular to the wear surface from Plate 2, all at 500x magnification. (a) Near-surface, (b) approximately 0.010" below the surface, (c) approximately 0.045" below the surface, and (d) approximately 0.065" below the surface. The images show severe plastic shearing at the surface, and decreasing disturbance to the microstructure with increasing depth.

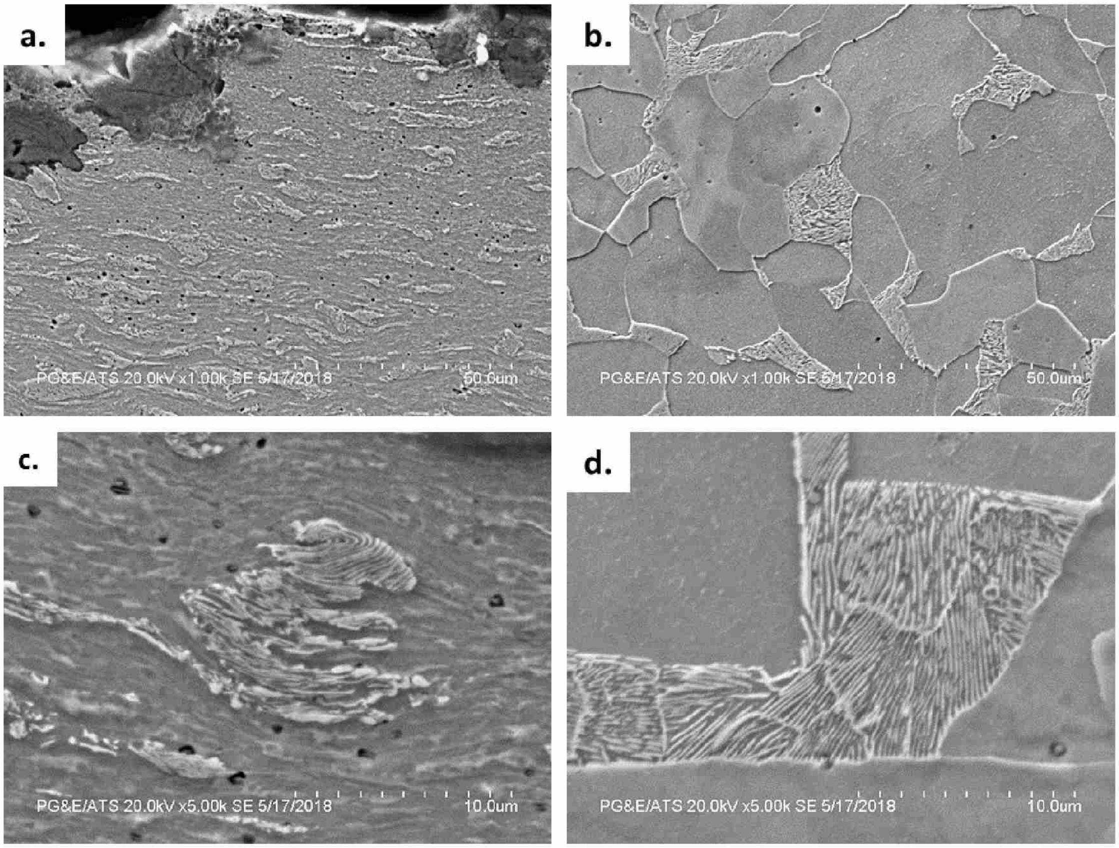

Figure 13: Scanning electron micrographs from the etched cross-section perpendicular to the wear surface of Plate 2. (a, c) From near the surface at 1,000x and 500x, and (b, d) from the bulk microstructure at 1,000x and 5,000x. Images a) and c) show severe breakup of the pearlite regions. Images b) and d) show large, intact pearlite colonies.

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Table II: Results of mechanical testing performed on Plates 2, 4, and 6.

Tensile Testing		**Plate 2**	**Plate 4**	**Plate 6**	**ASTM A7-42**	**ASTM A36-14**
Tensile Strength (n=1)	ksi	65.8	62.0	66.8	60-72	58-80
Yield strength (n=1)	ksi	43.4	36.7	40.5	0.5 Tensile / 33 min.	36 min.
Elongation (n=1, g=1")	%	36	43	38	22 min.*	23 min.*
Hardness		**Plate 2**	**Plate 4**	**Plate 6**	**ASTM A7-42**	**ASTM A36-14**
Average (n=10)	HRB	69.4	69.8	69.8	N/A	N/A
St. Dev (n=10)	HRB	1.7	1.7	1.3	N/A	N/A

* Minimum requirements vary by gauge length, plate width and thickness. Since the original plate width is not known, and the sample geometry limited gauge (g) to 1", the standard requirement for 2" gauge is listed here.

Table III: Results of chemical analysis by OES / LECO.

Element	**Plate 2**	**Plate 4**	**Plate 6**	**ASTM A7-42**	**ASTM 36-14**
Carbon, % max.	0.20	0.20	0.24	0.20-0.35	0.29
Mn, % max.	0.37	0.40	0.43	N/A	N/A
Phosphorous, % max.	0.008	0.008	0.010	0.06	0.04
Sulfur, % max.	0.025	0.026	0.058	0.05	0.05
Silicon, % max.	<0.005	0.006	≤0.005	N/A	0.40
Copper, % min.*	0.31	0.31	0.34	0.20	0.20

* When copper steel is specified

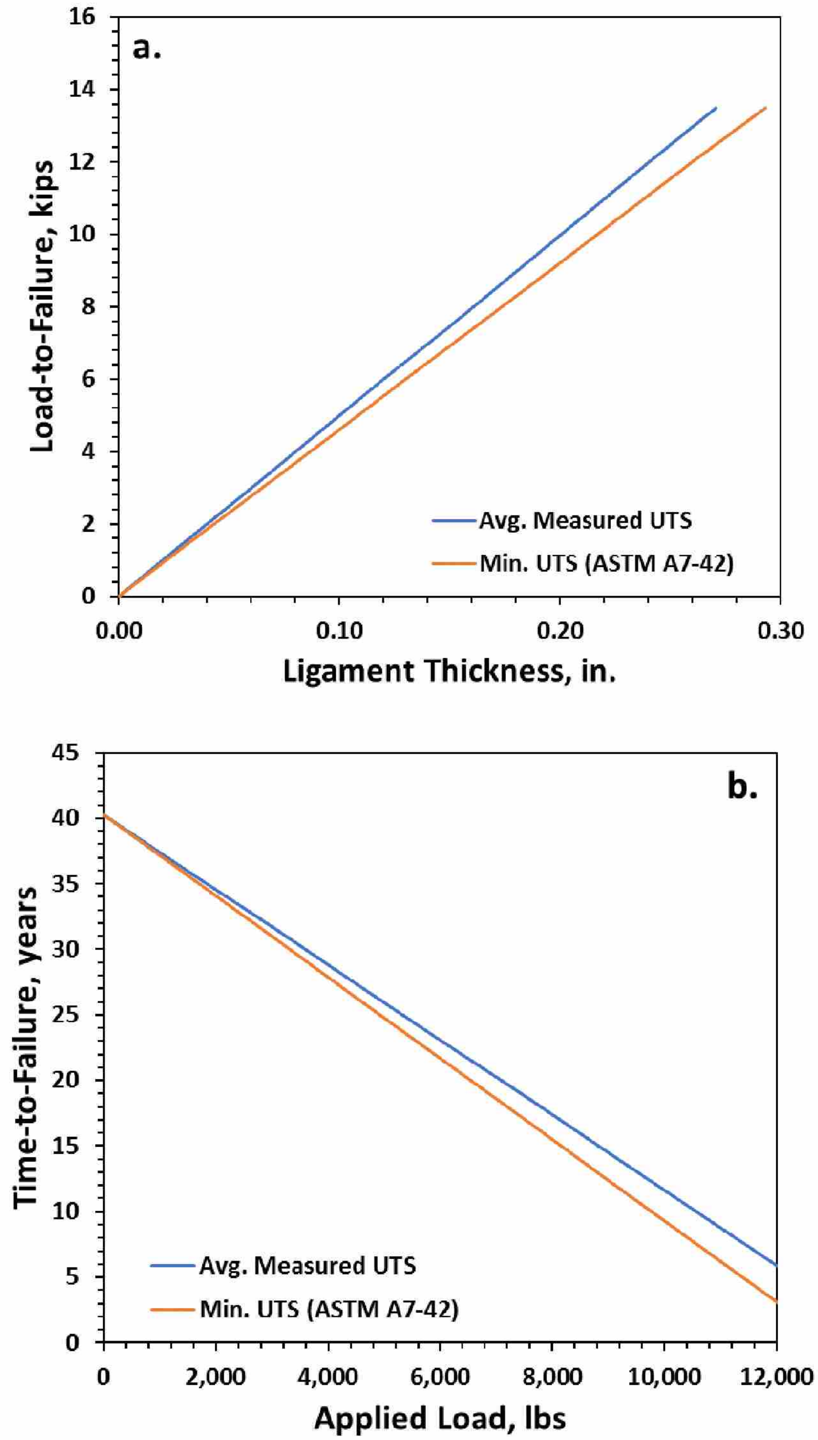

Figure 14: Results of mechanical calculations showing a) load-to-failure versus ligament thickness, and b) time-to-failure versus applied load. Both calculations assume shear tear-out and estimate shear rupture strength to be 60% of UTS. Time-to-failure assumes the wear rate to be 0.007"/year starting from the minimum observed ligament thickness (0.282").

Table IV: Time-to-failure versus load for the suspension plates, calculated per Eqs. (2) and (3) and based upon: i) wear rate of 0.007"/year, ii) current ligament thickness of 0.282", iii) UTS of 60 ksi, iv) shear rupture strength of 0.6*UTS per ANSI/AISC 360-16. The calculations assume that the wear will progress until the component fails by shear tear-out, and neglects the negative contribution of possible future cracking (no cracking was observed at present).

Load, lbs	Time-to-failure, years
1,500	35.6
2,000	34.1
2,500	32.5
3,000	31.0
3,500	29.4
4,000	27.9
4,500	26.3
5,000	24.8
5,500	23.2
6,000	21.7
6,500	20.1
7,000	18.6
7,500	17.0
8,000	15.5
8,500	13.9
9,000	12.4
9,500	10.8
10,000	9.3
10,500	7.7
11,000	6.2

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Appendix A: Component Testing Information Sheet (CTIS)

Pacific Gas and Electric Company

Component Testing Information Sheet

Elec. Transmission
09/2017
TD-1957P-01-F01

Contact Name (LAN ID): [redacted]	
Phone: [redacted]	PM# 31385452
Supervisor: [redacted]	PM operation #
Phone: [redacted]	CAP #114451180
Description of Component and Reason for Submission: (tell the story) PARKWAY- MORAGA 230KV 020/115. These suspension plates were removed and replaced today. The Bahia -Moraga side is scheduled for this Monday. Not sure if this is idiosyncratic to this span and this tower, but it might be something for asset management to review. I would also consider making this tower a double-deadend to avoid this in the future.	
GPS Latitude:	GPS Longitude:
Manufacturer: TBD	PG&E Drawing #:
Incident Date/Time:	Date Installed: TBD
Weather Conditions Contributing to Incident: Temperature: °F Wind: Yes Lightning: NA Precipitation: Other:	
Terrain Description, e.g. valley, ridge top, trees/height: Ridge Top Constant High to Med winds over Hwy 24 crossing	

Structure Numbers	
Conductor	Size: Span Length: Sag: Tension (lbs):
Line Load (amps)	At Failure Time: NA Normal: NA Emergency: NA
Vibration Dampers	Type: NA Distance from structures:NA
For Sleeves	Type: Twist, Compression, Moused NA Distance to structure: NA
For Insulators	Type: Polymer, Glass or Ceramic Cleaning Schedule: Ceramic Age: Last Cleaned:
For Hardware	Hot End/Cold End: Suspension/Dead End: Suspension
Proximity to sources of contamination and moisture, i.e., farming, industrial, highway, ocean, lake, marsh:	

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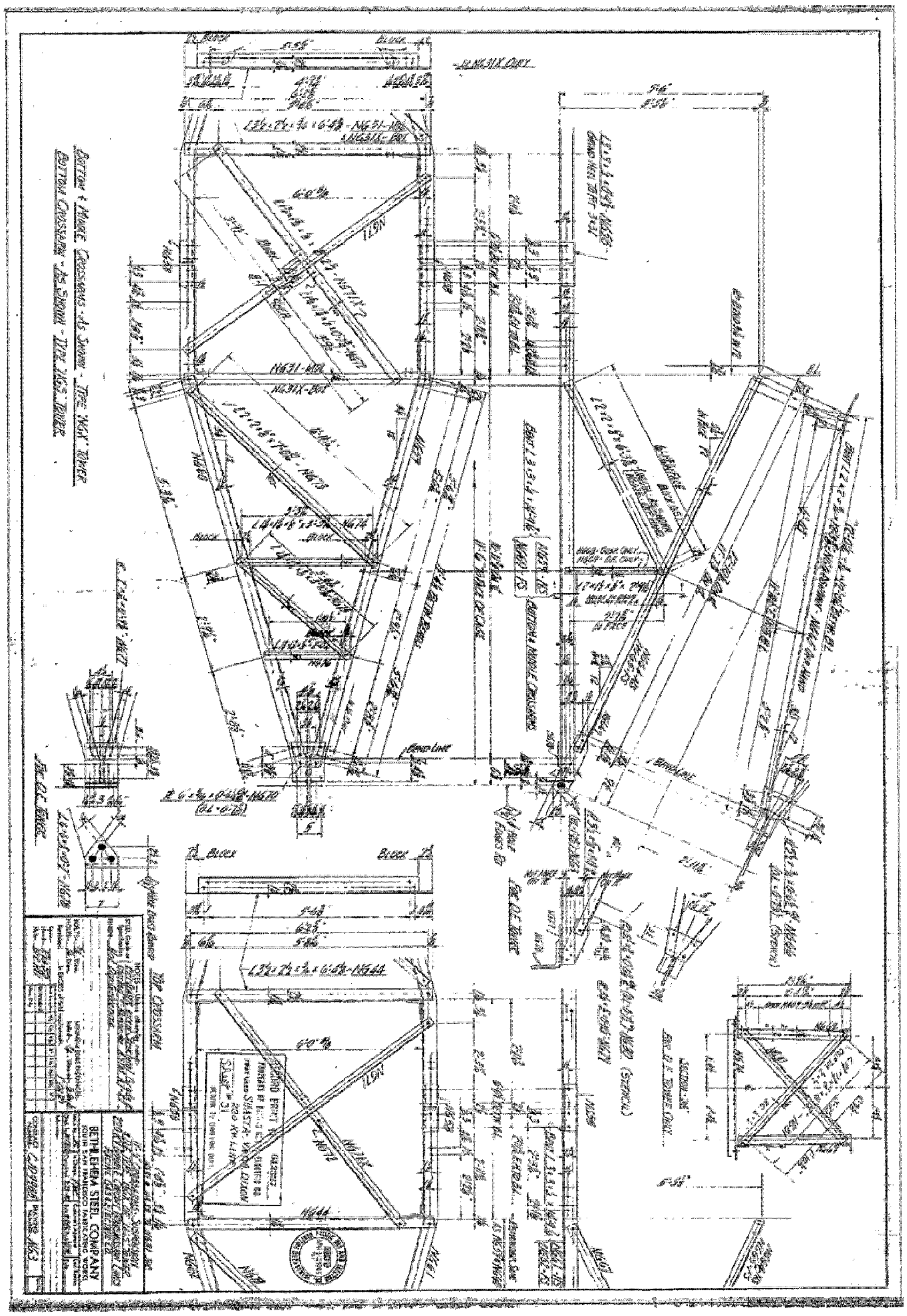
Appendix B: Engineering Drawing NG3 (1946)



Appendix C: Anamet Report 5005.5872, Tensile and Chemical Testing

LABORATORY CERTIFICATE

Anamet, Inc

	May 24, 2018
LABORATORY NUMBER:	5005.5872
CUSTOMER AUTHORIZATION:	Credit Card
DATE SUBMITTED:	May 21, 2018
REPORT TO:	Pacific Gas & Electric Company Attn: [redacted] 3400 Crow Canyon Road San Ramon, CA 94583

SUBJECT:

Three zinc-coated plate coupons were submitted for chemical analysis and tensile testing. The samples were identified as: A2, B2 and C2.

SPECTROCHEMICAL ANALYSIS:

(Reported as Wt. %)

		A2	B2	C2
Aluminum	(Al)	<0.005	<0.005	<0.005
Carbon*	(C)	0.20	0.20	0.24
Chromium	(Cr)	0.07	0.07	0.08
Columbium	(Cb)	<0.005	<0.005	<0.005
Copper	(Cu)	0.31	0.31	0.34
Manganese	(Mn)	0.37	0.40	0.43
Molybdenum	(Mo)	0.01	0.01	0.02
Nickel	(Ni)	0.13	0.13	0.14
Phosphorus	(P)	0.008	0.008	0.010
Silicon	(Si)	<0.005	0.006	≤0.005
Sulfur*	(S)	0.025	0.026	0.058
Titanium	(Ti)	<0.005	<0.005	<0.005
Vanadium	(V)	<0.005	<0.005	<0.005

*Determined by LECO combustion

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San Ramon, CA 94583

Report #: 413.62-18.25

Anamet, Inc

LABORATORY CERTIFICATE

Laboratory No. 5005.5872

TENSILE TEST
(ASTM A 370-17)

Specimen ID	A2	B2	C2
Dimensions of Specimen (in.)			
Width	0.260	0.247	0.243
Thickness	0.612	0.616	0.613
Area (in^2)	0.159	0.152	0.149
Tensile Strength (psi)	65800	62000	66800
Yield Strength (psi)*	43400	36700	40500
Elongation in 1.0" Gage (%)	36	43	38

*0.2% Offset

This testing was completed on May 24, 2018 and was performed in accordance with the customer's authorization.

Submitted by:
[redacted]

gm

Quality Manager

Applied Technology Services
34●● Crow Canyon Road
San Ramon, CA 94583

Report #: 413.62-18.25

Appendix D: Engineering Drawing 3008548, R1 (2013)